Final Operation and Maintenance Plan
Final (100% Complete) Design Report

Groundwater Control Operable Unit
Hagen Farm Site
Stoughton, Wisconsin

Prepared for:

Waste Management of Wisconsin, Inc.

April 1995

FINAL
OPERATION AND MAINTENANCE PLAN

For

HAGEN FARM SITE
GCOU RD/RA

STOUGHTON, WISCONSIN

Prepared For

Waste Management of Wisconsin, Inc.

April 1995

RUST Environment & Infrastructure
4738 North 40th Street
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Project No. 71803

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1.0 INTRODUCTION

This Groundwater Control Operable Unit (GCOU) Operation and Maintenance (O&M) Plan was prepared as a component of the Remedial Design/Remedial Action (RD/RA) for the Hagen Farm site. This GCOU O&M Plan provides guidelines for the long-term operation and maintenance of the Hagen Farm GCOU components. This O&M Plan was prepared in accordance with the Record of Decision (ROD) issued by the United States Environmental Protection Agency (USEPA) (September 1992) and the Unilateral Administrative Order (UAO) (with the attached Scope of Work (SOW)) (November 1992).

The components covered in the Hagen Farm GCOU O&M Plan are:

- Groundwater extraction system
- Groundwater treatment system
- Treated groundwater discharge system

This Hagen Farm GCOU O&M Plan was prepared prior to RA bidding, RA equipment section, and RA implementation; therefore, the construction "record" drawings, contractor submittals, and equipment lists will be attached as addenda. In addition, changes that may result during construction will be incorporated as addenda. The Remedial Investigation (RI) report and RD/RA Health and Safety Plan should be reviewed to obtain specific historical and safety related concerns.

2.0 DESCRIPTION OF GCOU RD COMPONENTS

2.1 GROUNDWATER EXTRACTION SYSTEM

The Hagen Farm GCOU groundwater extraction system will be installed and operated to control the identified groundwater plume in the on- and off-property areas. The Hagen Farm GCOU groundwater extraction system includes:

- Six groundwater extraction wells will be designed to depths as shown in the design submittal. Of the six groundwater extraction wells designed, four wells will initially be constructed and operated.

- Groundwater extraction well pumps to withdraw groundwater and provide sufficient "head" pressure to convey the pumped groundwater to lift stations or to the Hagen Farm GCOU treatment plant.

- Water level switches and pump controllers to operate the groundwater extraction well pumps.

- Piping to convey groundwater from extraction wells to the Hagen Farm GCOU treatment plant.

- Valves and meters to measure and adjust the groundwater extraction rate flow from the groundwater extraction wells. Valves will consist of globe and ball valves. Meters will include flow and pressure measuring meters.

2.2 GROUNDWATER TREATMENT SYSTEM

The Hagen Farm GCOU groundwater treatment system will be installed and operated to treat groundwater extracted by the groundwater extraction system to meet the discharge requirements established by the Wisconsin Department of Natural Resources (WDNR). The Hagen Farm GCOU treatment system components include:

- A pretreatment system to remove inorganic compounds from the extracted groundwater. The pretreatment system will remove inorganic compounds from the extracted groundwater by aeration, flocculation, settling, and clarification.

- An aerobic bioreactor treatment system to remove organic compounds from the extracted groundwater. The aerobic bioreactor will remove organic compounds by utilizing a fixed-film biological treatment technology.

- A sludge management system to remove sludges generated during operation of the pretreatment and aerobic bioreactor treatment systems.

- Instrumentation and control systems to operate and monitor the Hagen Farm GCOU systems.

2.3 TREATED GROUNDWATER DISCHARGE SYSTEM

The Hagen Farm GCOU treated groundwater discharge system will be installed and operated to convey treated groundwater to the discharge point. The Hagen Farm GCOU treated groundwater discharge system includes:

- Pumps to provide sufficient "head" pressure to convey the treated groundwater from the Hagen Farm GCOU treatment plant to the discharge point on the Yahara River.

- Piping to convey treated groundwater from the Hagen Farm GCOU treatment plant to the discharge point at the Yahara River.

- Valves and meters to measure and adjust the treated groundwater discharge rate flow as required. Valves will consist of globe and ball valves. Meters will include flow and pressure measuring meters.

3.0 NORMAL OPERATION AND MAINTENANCE

3.1 OPERATION TASKS

Operation tasks will be provided in the O&M Manual that will be prepared after selection of Hagen Farm GCOU equipment. The O&M Manual will provide equipment specific operational information regarding:

- System Start-up which will include information on system restart procedures
- System Monitoring including normal operating ranges for system components
- System Shut-down which will include shut-down procedures of the entire system or parts of the system when maintenance is required
- Forms for routine operations.

The O&M Manual will be provided as an addendum to this O&M Plan.

3.2 MAINTENANCE TASKS

Maintenance tasks will be described in the O&M Manual that will be prepared after selection of Hagen Farm GCOU equipment. The O&M Manual will provide equipment specific maintenance information regarding:

- System pre-start-up inspections requirements.
- Routine maintenance requirements and procedures. This will include a schedule for all routine maintenance and forms for recording the results of routine maintenance performed.
- Troubleshooting and corrective action requirements and procedures.
- Forms for routine maintenance.

The O&M Manual will be provided as an addendum to this O&M Plan.

3.3 ROUTINE MONITORING AND LABORATORY TESTING

3.3.1 Monitoring Task Description

Routine monitoring of the Hagen Farm GCOU will be conducted at on-site groundwater monitoring wells, treatment system influent and effluent waters, air emissions systems, and treatment system

generated sludge. Parameters for testing site groundwater monitoring wells, treatment system influent and effluent waters, and treatment system generated sludge are detailed in the Quality Assurance Project Plan (QAPjP) (Warzyn, July 1993, Volume IV of V).

3.3.2 Required Laboratory Testing

Required laboratory testing is detailed in the QAPjP.

3.3.3 Routine Groundwater Monitoring

This section of the O&M plan describes the groundwater sampling tasks, specifies the location(s) where these tasks will be conducted, and provides a draft schedule that shows the duration and frequency of sampling activities. Specific groundwater sampling and analytical methods are addressed in the Field Sampling Plan (FSP) which is included in the QAPjP.

The objectives of this monitoring program are to:

- Demonstrate the effectiveness of the Hagen Farm Groundwater Extraction and Treatment system in protecting private wells located around the Hagen Farm property by establishing hydraulic containment of the contaminant plume.

- Monitor changes in the concentration of chemical compounds associated with the Hagen Farm groundwater plume and document that progress toward meeting the cleanup objectives is being achieved.

- Monitor the rate and direction of groundwater flow.

The following subsections provide a general description of groundwater sampling locations and field sampling methods. Subsection 3.3.3.1 identifies those wells where static water level will be measured and describes how this water level data is to be utilized and reported. Subsection 3.3.3.2 identifies those monitoring wells and private wells from which samples of groundwater are to be collected and analyzed, describes the frequency and duration of this groundwater sampling, and summarizes the analytical methods to be used and the parameters to be analyzed for. A detailed description of field methods is provided in the FSP. Details regarding analysis of groundwater are provided in the QAPjP.

The groundwater monitoring program will consist of sampling groundwater and measuring water levels in each of the monitoring wells, along with field and laboratory testing of the samples. Wells included in the groundwater monitoring program are those listed in Table 3-1, and are shown on Figure 3-1.

3.3.3.1 Water Level Measurements

Static water level measurements will be taken at all monitoring wells (not including private wells) shown on Table 3-1. Water level measurement methods are detailed in the FSP (Attachment A of the QAPjP).

As an alternate to the water level monitoring frequency specified in Section II.B.2.a(3) of the U.S. EPA Scope of Work, it is proposed that following start-up of the groundwater extraction and treatment system, water levels be recorded at monitoring wells monthly for the first six months, quarterly for the next six months, and annually thereafter until shutdown of the extraction system.

Pumping rates will be correlated to water levels during the first six months to refine the aquifer modeling assumptions that were used to design the groundwater extraction system. Plume capture will be monitored thereafter by maintaining the required pumping rates and performing water level monitoring.

It is anticipated that six months will allow sufficient time for the groundwater flow system to stabilize following extraction system start-up. This will also allow sufficient time for initial adjustments to extraction well pumping rates, as needed. The water level measurements after the first six months will be used to confirm or modify required pumping rates, as needed.

In addition, following shutdown of the extraction system, water level measurements will be collected concurrent with each groundwater sampling event.

Water level data will be evaluated by constructing water table maps and potentiometric surface maps with water level data collected from water table wells and piezometers. The vertical component of groundwater flow will be evaluated by preparing potentiometric contours in cross-section. Water level data collected during the RA will be useful in evaluating the effectiveness of the extraction and treatment system in protecting private well supplies.

3.3.3.2 Groundwater Sampling and Analysis

Groundwater Sampling Locations

The proposed groundwater monitoring program is intended to detect changes in the chemical concentrations of groundwater at and near the Hagen Farm property. It will include field and laboratory testing of samples collected from select site monitoring wells on and off the Hagen Farm property. Analytical results obtained during the monitoring period will be used to meet the objectives stated in Section 3.3.3 of this plan. If during the performance of the groundwater monitoring, additional information indicates that the program is inadequate to detect changes in the chemical concentrations in groundwater, or to determine the effectiveness of the groundwater extraction system, WMWI may modify the sampling location, frequency, duration, and/or the parameters analyzed for, by written notification to and approval by Agencies.

The wells listed in Table 3-1 constitute the proposed groundwater monitoring for the Hagen Farm GCOU.

Existing and future monitoring wells and piezometers not included in the sampling list described above will be left in place and not permanently abandoned unless or until necessary. If well abandonment is necessary, U.S. EPA and WDNR will be notified. Wells will not be abandoned without U.S. EPA/WDNR approval.

The proposed monitoring locations were selected to detect changes in water quality near the water table, in the unconsolidated deposits between the water table and bedrock, and in the bedrock. These well locations were selected based on a 3-dimensional evaluation of the aquifer along with the findings of the Remedial Investigation and subsequent groundwater monitoring events, to monitor the groundwater quality upgradient, cross-gradient, and immediately downgradient of the Hagen Farm source area and the hydraulic effects of the groundwater extraction system. The rationale for selecting the wells in and along the groundwater plume is that these wells will be sufficient to detect changes in chemical concentrations in the groundwater plume, and to monitor the effectiveness of the groundwater extraction and treatment system. These wells have been selected to provide an indication of groundwater quality trends in and adjacent to the groundwater plume, thereby assessing the effectiveness of the extraction and treatment system in protecting private water supplies.

Groundwater Sampling Frequency

Following start-up of the groundwater extraction system, selected monitoring wells will be sampled on a quarterly basis for a minimum of three years. After the first three years of monitoring, a reduced frequency to semi-annual sampling is proposed as sufficient to demonstrate the effectiveness of the groundwater extraction system.

Private wells will be sampled on an annual basis following start-up of the groundwater extraction system. Private well sampling will continue through the operation of the extraction system.

Following shutdown of the groundwater extraction system, selected monitoring wells will be sampled monthly for the first six months, and once every other month for the second six months. If the first year of monitoring indicates cleanup standards have been met, monitoring will be conducted on a quarterly basis for the next two years. Following three years of post shutdown monitoring, a proposal will be made to U.S. EPA for semi-annual monitoring. Upon approval from the U.S. EPA, the Respondent may cease groundwater monitoring.

Private well sampling will continue on an annual basis following shutdown of the groundwater extraction system. Private wells surrounding the site are located a sufficient distance from the groundwater plume to be outside the expected zone of direct influence by the extraction system. Annual monitoring during the post shutdown period will be sufficient to detect changes in water quality at the private well sources.

Groundwater monitoring as described above will continue until it is demonstrated that cleanup standards have been continually satisfied at the "point of compliance" as described in

TABLE 3-1

GROUNDWATER MONITORING WELLS, PIEZOMETERS AND PRIVATE WELLS

Monitoring Wells and Piezometers:

MW1	OB8M	P29B
MW7	OB11M	P29C
MW22	P7B	P30B
MW23	P17B	P30C
MW26	P17C	P32B
MW27	P17DR2	P33B
MW29	P22B	P34B
MW30	P26B	P35B
MW32	P26C	P36B
MW33	P27B	P37B
MW34	P28B	P38B
MW35	P28C	P39B

Private Wells:

Sundby (PW01)
Sundby Sand and Gravel (PW03)
Fosdahl (PW05)
Van Deusen (PW07)
Stoughton Conservation Club (PW09)
Gjertson (PW11)
Kway Insulation (PW02)
Gullickson (PW04)
Lee (PW06)
Quam (PW08)
Sagmoen (PW10)

Section II.B.2.b(15) of the U.S. EPA Scope of Work. The "point of compliance" will be at monitoring locations from the edge of the landfill cap and downgradient, for a period of 30 years following shutdown of the groundwater extraction system. The cleanup standards are those referenced in Section II.B.2.b(16) of the U.S. EPA Scope of Work. Additional cleanup standards, consistent with the National Contingency Plan and Record of Decision, may be specified by the U.S. EPA for constituents detected during monitoring that lack numeric standards under Chapter NR 140, WAC.

As provided under Section II.B.2.b(16) of the U.S. EPA Scope of Work and Chapter NR 140.28, WAC, the U.S. EPA may establish an Alternative Concentration Limit (ACL) as a cleanup standard, if, based on site-specific monitoring data collected during the groundwater monitoring program, the U.S. EPA determines it is not technically and economically feasible to achieve PALs for a specific constituent.

Refer to the FSP (Attachment A to the QAPjP) for additional information pertaining to the sampling of groundwater.

Groundwater Sample Analysis

The groundwater samples collected as part of the groundwater monitoring program will be analyzed in the field and analytical laboratory for a variety of parameters.

Field analyses to be performed during each sampling round described in the previous section will include pH, specific conductance, and temperature.

The "full laboratory analyses" to be performed during each sampling round, semi-annually for the first five years, and every three years thereafter, at the wells described in the previous section, will include:

- U.S. EPA Target Compound List (TCL) organics plus tetrahydrofuran (THF)
- U.S. EPA Target Analyte List (TAL) inorganics
- Groundwater Quality Indicator Parameters including: alkalinity, hardness, chloride, and chemical oxygen demand.

The "partial laboratory analyses" to be performed during the remaining sampling rounds will consist of the following constituents: benzene, 1,1-dichloroethene, ethylbenzene, THF, toluene, xylenes, vinyl chloride, arsenic, barium, iron, lead, manganese, and mercury. For example, during the second year of monitoring following start-up of the groundwater extraction system, monitoring wells will be sampled on a quarterly basis. Therefore, during the second year the "full laboratory analyses" will be performed during the first quarter and the "partial laboratory analyses" will be performed during the remaining three quarters. Private wells, which are scheduled to be monitored annually during the second year, will undergo "full laboratory analyses" only.

3.3.3.3 Groundwater Monitoring Reports

A brief report transmitting results of groundwater monitoring activities will be submitted to the U.S. EPA within 60 days after receipt of laboratory data following each groundwater quality monitoring event. The report will include:

- Field data collected during sampling.
- Copies of chain-of-custody forms.
- Laboratory Quality Control Summary Sheets.
- Data quality review narrative.
- Water level measurements.
- Comparison of analytical results to PALs and ESs listed in Chapter NR 140, WAC.

On an annual basis, groundwater quality trends will be evaluated and included in the groundwater monitoring report. The effectiveness of the monitoring system in protecting private water supplies will also be addressed.

Private Well Monitoring Reports

Private well monitoring results will be incorporated into the groundwater monitoring report (monitoring wells). The information to be provided for private wells will be the same as listed above for monitoring wells, with the exception of water level measurements (which are not taken at private wells).

In addition to the above, raw data results for the private well sampling will be submitted to U.S. EPA within one week following quality assurance/quality control of the data.

3.3.3.4 Cessation of Operations

Operation of the Hagen Farm GCOU will cease at a point in time when it is determined that further operation of the GCOU will not decrease contamination at the site. The following criteria will be used in the decision making process to cease operation of individual groundwater extraction wells or the entire GCOU system:

- A decrease of target organic and inorganic compounds has occurred at either individual groundwater extraction wells (below WDNR NR 140 Preventive Action Limits (PALs) based on groundwater monitoring analytical data or an asymptotic plateau has been reached.

- Groundwater contaminant concentrations do not increase at individual wells following system shutdown based on groundwater monitoring analytical data.

- Target organic or inorganic compounds are below the analytical method detection limits at individual extraction wells based on analytical data.

Monitoring of Hagen Farm groundwater quality will continue on an annual basis for 5 years after cessation of operation of the GCOU. If target organic or inorganic compounds concentrations do not increase in individual extraction wells, the Hagen Farm GCOU will be permanently shutdown. Procedures to permanently shutdown the Hagen Farm GCOU will be determined at that time.

3.3.4 Effluent Monitoring

The effluent from the Hagen Farm GCOU groundwater treatment system will be monitored for the parameters in Table 3-2. Daily grab samples will be collected during the first week of operation following biological fixed-film reactor acclimatization. Grab samples will be collected weekly for the next three weeks and monthly for the next five months. The next two-and-one-half years of monitoring will be quarterly, to coincide with the groundwater monitoring events. Semi-annual sampling will be conducted thereafter, in accordance with the groundwater monitoring schedule.

Table 3-2
GCOU Effluent Monitoring Analytical Parameters and Reporting Units
Hagen Farm GCOU
April 1995

Conventional Parameters	Semi-Volatile Organic Compounds
Biological Oxygen Demand (mg/l)(1)	2,4-Dimethylphenol (ug/l)
Chemical Oxygen Demand (mg/l)	4-Chloro-3-Methylphenol (ug/l)
Total Organic Carbon (mg/l)	Bis(2-ethylhexyl)phthalate (ug/l)
Total Suspended Solids (mg/l)	Diethyl Phthalate (ug/l)
Flow (gpm)	Naphthalene (ug/l)
Nitrate and Nitrite (mg/l as N)	Phenol (ug/l)
Ammonia (mg/l as N)	
Phosphorus (mg/l as Total P)	
Temperature (degrees C)	
pH (pH units)	
Dissolved Oxygen (mg/l)	
Volatile Organic Compounds	**Metals**
1,4-Dichlorobenzene (ug/l)	Arsenic* (ug/l)
Benzene*(ug/l)	Barium* (ug/l)
Bis(2-chloroisopropyl)ether (ug/l)	Copper (ug/l)
1,1-Dichloroethylene* (ug/l)	Iron* (ug/l)
Ethylbenzene* (ug/l)	Lead* (ug/l)
Tetrahydrofuran* (ug/l)	Manganese* (ug/l)
Toluene*(1) (ug/l)	Mercury* (ug/l)
Vinyl Chloride* (ug/l)	Nickel (ug/l)
Xylenes, Total* (ug/l)	Zinc (ug/l)

NOTES:

BOD will be analyzed for until a correlation between BOD and COD is established for effluent from the GCOU.
**Parameter listed in SOW Table 1.*

4.0 ALTERNATE OPERATION AND MAINTENANCE

4.1 SYSTEM(S) FAILURE

System(s) failures and additional resource requirements for alternate O&M of the Hagen Farm GCOU will be addressed in the O&M Manual that will be developed after selection of GCOU equipment and will be based on manufacturer recommendation.

4.2 POLLUTION PREVENTION

The Hagen Farm GCOU has been designed to minimize the potential release of pollutants to the environment. All drains in the building route to the recycling sump. The chemical storage area has been designed with secondary containment to prevent the release of chemicals to the environment. The chemical storage area's secondary containment will provide more than 150 percent capacity of the largest container in this area. All process systems are equipped with high level sensors which will shutdown the system to prevent an overflow and possible release of materials.

5.0 CORRECTIVE ACTION

The Hagen Farm GCOU is dependent on the integrity of the GCOU components. Any damage to the GCOU components will result in corrective actions to the GCOU. Damage to the system components and corrective action necessary will be addressed in the O&M Manual. Indication that corrective action is necessary will be provided by the Hagen Farm GCOU Main Control Console (MCC). If any of the components sensors of the GCOU fail, the MCC will activate the telemetry system. The telemetry system will activate the automatic dialer which will send a message to the Hagen Farm GCOU operator. The Hagen Farm GCOU operator will then access the telemetry system to identify which component sensor failed and report the information to WMWI. The Hagen Farm GCOU operator will initiate corrective action within 24 hours of receipt of this failure notification.

5.1 GROUNDWATER EXTRACTION AND TREATMENT SYSTEM CORRECTIVE ACTION

Groundwater extraction system deficiencies will be addressed in accordance with SOW Section II.B.2.b(13), "Correction of Deficiencies."

WMWI is required to meet the WDNR-established effluent limits for the effluent from the groundwater treatment system. If the effluent limits are not met at any time, the following procedures may be followed:

- WMWI will collect an effluent confirmaion sample and send it to a laboratory for analysis.
- If the exceedance is confirmed, WMWI will notify USEPA of the exceedance within 24 hours of receipt of effluent confirmation sample results. WMWI will discuss non-routine operational adjustments or maintenance which could be performed to correct the exceedance.
- Non-routine operational adjustments or maintenance will be performed to correct deficiencies.
- Once non-routine operational adjustments have taken effect or maintenance activities are completed, WMWI will collect an effluent sample.
- If the extraction system is temporarily shut down, the procedure below will be followed.

If for any for any reason the operation of the Hagen Farm GCOU is interrupted or stopped, except for routine maintenance, the USEPA and the WDNR will be notified within 24 hours of the shutdown. The USEPA and WDNR will be notified initially by telephone. Written confirmation of the shutdown will be completed within five days after telephonic notification. The USEPA and the WDNR will be informed of the nature and cause of the interruption or shutdown in operation. The notification will also include the estimated length of time the Hagen Farm GCOU will be out of service.

For routine maintenance of the Hagen Farm GCOU that will require shutdown for a period longer than 24 hours, USEPA and the WDNR will be notified, in writing, 48 hours prior to the shutdown. USEPA and the WDNR will be informed of the nature of the maintenance to be performed and the estimated length of time the system will be shutdown.

6.0 HEALTH AND SAFETY PLAN

An addendum to the Hagen Farm GCOU RD/RA Health and Safety Plan (RUST E&I, August 1993) will be developed after selection of GCOU equipment. This addendum will address the physical and chemical hazards associated with the operation and maintenance of the Hagen Farm GCOU.

7.0 EQUIPMENT DESCRIPTION

A description of the Hagen Farm GCOU equipment will be provided in the O&M Manual which will be developed after selection of equipment vendors.

8.0 RECORDS AND REPORTING

As discussed in Sections 3.1 and 3.2, operating logs and forms for O&M will be provided in the O&M Manual. In accordance with SOW Section III, Task II, the O&M Manual will also include:

- A description of laboratory tests and their interpretation.
- Laboratory records.
- Emergency reporting mechanisms.
- Records for operating costs.

Progress reports for O&M will be prepared semi-annually in accordance with SOW Section III, Task V. Progress reports will include:

- Copies of operating logs and forms.
- Copies of maintenance logs and forms.
- A summary of O&M activities for the period.
- A summary of modifications to procedures prescribed in the O&M Manual for the period.
- A summary of meetings during the period.
- A summary of problems and actions taken to resolve the problems.
- Personnel changes.
- Upcoming events.

PROJECT
10006420

GROUNDWATER MONITORING PLAN

GROUNDWATER CONTROL OPERABLE UNIT

HAGEN FARM
TOWN OF DUNKIRK, WISCONSIN

JULY 1993

WASTE MANAGEMENT OF WISCONSIN, INC.
WESTCHESTER, ILLINOIS

• • •

PREPARED BY:
WARZYN INC.
MADISON, WISCONSIN

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GROUNDWATER MONITORING PLAN

PROJECT
10006420

GROUNDWATER MONITORING PLAN

GROUNDWATER CONTROL OPERABLE UNIT

HAGEN FARM
TOWN OF DUNKIRK, WISCONSIN

JULY 1993

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GLOSSARY, ACRONYMS, ABBREVIATIONS

GLOSSARY

The following terms have the following meanings as used in the Groundwater Control Operable Unit Remedial Design Work Plan:

Hagen Farm	The approximate 28 acre former Hagen Farm property located in the Town of Dunkirk, Dane County, at 2318 County Highway A, approximately one mile east of the City of Stoughton, Wisconsin.
Off-property	Property outside the Hagen Farm property boundary.
On-property	Property within the Hagen Farm property boundary.
Site	The areal extent of waste disposal and contamination, as well as suitable areas in close proximity necessary for implementation of the remedy.
work plan(s)	Individual work plan or plans which comprise the Remedial Design Work Plan for the Groundwater Control Operable Unit. Individual work plans include: 1) Pump Test Plan; 2) Bioassay Test Plan; 3) Groundwater Monitoring Plan and QAPjP; 4) Wetlands Investigation Plan; 5) Treatability Study Plan; and 6) Background Water Quality Study Plan.
Work Plan	The overall Remedial Design Work Plan for the Groundwater Control Operable Unit. The Work Plan essentially consists of the six individual, primary Work Plans identified above.
Aquifer System	This refers to the combined glacial and bedrock aquifers.

ACRONYMS

The following acronyms are used in the Groundwater Control Operable Unit Remedial Design Work Plan:

BAT	Best Available Control Technology Economically Available
Consent Order	Administrative Order by Consent
CQA	Construction Quality Assurance
GCOU	Groundwater Control Operable Unit
IC25	25% Inhibition Concentration
LC50	50% Lethal Concentration
NPL	National Priorities List
NR	Natural Resources
O&M	Operation and Maintenance
QAPjP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RUST	RUST Environment and Infrastructure, formerly SEC Donohue, Inc.
SCOU	Source Control Operable Unit
SOW	Scope of Work
UAO	Unilateral Administrative Order
Uniroyal	Uniroyal Plastics Company, Inc.
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UV	Ultraviolet
WAC	Wisconsin Administrative Code
Warzyn	Warzyn Inc.
WDNR	Wisconsin Department of Natural Resources
WMWI	Waste Management of Wisconsin, Inc.
WPDES	Wisconsin Pollutant Discharge Elimination System

ABBREVIATIONS

The following abbreviations are used in the Groundwater Control Operable Unit Remedial Design Work Plan:

cf	cubic feet
cfm	cubic feet per minute
cm/s	centimeters per second
cy	cubic yard
dia	diameter
ft	feet, foot
gal	gallon(s)
gpm	gallons per minute
h	hour
in.	inch
mg/L	milligrams per liter
ppb	parts per billion
ppm	parts per million
sf	square foot, square feet
ug/L	micrograms per liter

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1

INTRODUCTION

This Groundwater Monitoring Plan (GMP) addresses the requirements specified in Sections II.B.2.a.(2) through II.B.2.a.(6) of the U.S. EPA Scope of Work (Appendix I of this Work Plan for the Hagen Farm Site GCOU). This plan describes the groundwater sampling tasks, specifies the location(s) where these tasks will be conducted, and provides a schedule that shows the duration and frequency of sampling activities. Specific sampling and analytical methods are addressed in the Field Sampling Plan (FSP) (Attachment A of the QAPjP). A summary of the Groundwater Monitoring Program sampling activities, including sample matrix, frequency and parameters, is provided in QAPjP Table 1. The GMP is not intended to be a stand alone document, and as such contains references to other plans contained in the Hagen Farm GCOU RD Work Plan.

The objectives of this monitoring program are to:

- Demonstrate the effectiveness of the on and off-property Groundwater Extraction and Treatment system in protecting private wells located around the Hagen Farm property, and in achieving the cleanup standards as set forth in Section II.B.2.b.(16) of the U.S. EPA SOW (Appendix I of the Work Plan).

- Monitor changes in the concentration of chemical compounds listed in Table 1 (Section II.B.2.a.(4)) of the U.S. EPA SOW (Appendix I of the Work Plan).

- Monitor the rate and direction of groundwater flow.

- Further characterize the distal limits and base of the off-property portion of the contaminant plume.

Section 1 of this document provides an introduction to the GMP and explains the objectives of this monitoring program. Section 2 contains the following tasks that comprise the Scope of Work for the GMP:

- Evaluation of Existing Monitoring Wells and Staff Gauges
- Groundwater Quality Borings and Monitoring Wells
- Water Level Measurements
- Groundwater Sampling and Analysis

Section 3 provides details for preparation of the required reports and Section 4 contains a listing of the references used in preparing this document.

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2

SCOPE OF WORK

The Scope of Work describes the tasks that are to be conducted as part of the GMP and how each task is to be implemented. Each subsection provides a general description of sample locations and field methods. Subsection 2.1 identifies existing wells and staff gauges that are to be evaluated and describes how this information is to be utilized and reported. Subsection 2.2 identifies the location(s) where new monitoring wells and water quality borings are to be located, how they are to be drilled and sampled, how wells are to be installed, and how this field effort is to be reported. Subsection 2.3 identifies those wells and staff gauges where static water level will be measured and describes how this water level data is to be utilized and reported. Subsection 2.4 identifies those monitoring wells and private wells from which samples of groundwater are to be collected and analyzed, describes the frequency and duration of this groundwater sampling, and summarizes the analytical methods to be used and the parameters to be analyzed for. A detailed description of field methods is provided in the FSP (Attachment A of the QAPjP). Details regarding analysis of groundwater are provided in the QAPjP.

2.1 EVALUATION OF EXISTING MONITORING WELLS AND STAFF GAUGES

During the collection of the initial round of water level measurements (see section 2.3) each existing monitoring well, on-property pumping test observation well and extraction well, and staff gauge will be evaluated using the methods described in section 5.2 of the FSP (Attachment A of the QAPjP). Resurveying, redevelopment, repairs, abandonment, and/or replacement may be required of one or more monitoring wells or staff gauges based on the findings of this evaluation.

2.2 GROUNDWATER QUALITY BORINGS

The groundwater quality borings and wells will be drilled, installed, developed, and/or abandoned (as needed) in accordance with Chapter NR 141, WAC (including the utilization of WDNR forms and other documentation as required in accordance with NR 141.23 WAC, and WMWI Monitoring Well Construction and Development Guidelines (1990) (Attachment A), whichever is the more stringent. The proposed work scope consists of drilling a minimum of five groundwater quality borings and installing six monitoring wells at the approximate locations shown on Drawing B3. Dual tube reverse circulation air rotary and/or hollow stem auger drilling methods will be used. Drilling and well installation details are presented in Section 5 of the FSP - Attachment A of the QAPjP. Groundwater samples will be collected at 10 ft intervals and analyzed with a field GC for tetrahydrofuran (THF). This information will be used to select well screen intervals. Since these analytical results are being used for screening purposes only, the analyses will be conducted at a Data Quality Objective Level II (DQO-Level II). This same approach was approved by the U.S. EPA and used during the Hagen Farm RI/FS (see the Work Plan Addenda for the Hagen Farm RI/FS dated April 10, 1990 and October 29, 1990). DQO-Level II will help to reduce analytical time for this portion of the RD field activities. Sampling locations and specific sampling methods and equipment requirements are detailed in Section 5 of the FSP (Attachment A of the QAPjP). This data will be used to select appropriate locations and screened intervals for the off-property pumping test extraction well and permanent groundwater extraction system monitoring wells.

2.2.1 Borings

Drawings 10006420-B3 shows the proposed locations for the five groundwater quality borings (P36B, P39B, P38B, P37B, and OB08D). Borings are located in two lines that run cross-gradient of groundwater flow. The most southerly line of two borings (P36B and P39B) is located approximately 800 ft south and a maximum distance of 1400 ft west of monitoring well nest 32. Borings in this line are to be spaced approximately 500 ft apart and in-line with former test boring TB1 (shown on Drawing 10006420-B2) in which THF was detected at a concentration of 923.0 ppb (see the Hagen Farm RI Report, Warzyn, 1991) at an elevation of 740 ft MSL (depth of 79 ft) and 157.0 ppb THF (see the Hagen Farm RI Report, Warzyn, 1991) at an elevation of 660 ft MSL (depth of 97 ft). The second line of three borings (P38B, P37B, and OB08D) is to be located approximately 700 ft south of monitoring well nest 29. Anticipated total borehole depths are listed in Table A1 and the approximate location of each borehole is illustrated in Drawing 10006420-B3 These estimated depths and locations may change based on the findings of the groundwater quality boring results and current

field conditions. Section 5.2.3.4 of the FSP provides a description of the criteria to be used to determine the exact locations and total borehole depths.

If drilling into bedrock is required, then temporary overshot casing will be installed approximately 5 ft into the top of bedrock in each of the borings to prevent potential cross contamination of the bedrock from the overlying glacial aquifer. This temporary casing will remain in place until the borehole is abandoned or until a monitoring well is installed.

Boring locations were selected based on three criteria:

- Current orientation and areal distribution of the contaminant plume, as described in the Hagen Farm RI Report (Warzyn, 1991)
- Subsurface geology and stratigraphy
- Accessibility for drilling and sampling

2.2.2 Additional Borings and Permanent Monitoring Wells

Soil and rock descriptions, natural gamma ray responses, and results of the THF GC analyses from the five groundwater quality borings will be reviewed. The findings of this review, in conjunction with water quality results from previous studies and knowledge of local geology, will be used to determine if additional borings are required and their locations. This process will continue until it has been determined that the distal limits of the THF contaminant plume have been sufficiently characterized.

The actual number (as opposed to the proposed number) and location of permanent monitoring wells will be determined from data gathered during the drilling and sampling of the groundwater quality borings. As groundwater quality boring data becomes available, U.S. EPA will be contacted by WMWI to discuss the results of the boring program and recommended placement of new monitoring wells. Upon U.S. EPA approval, the new monitoring wells will be installed. Monitoring well drilling, installation, and development methods are discussed in detail in Section 5 of the FSP (Attachment A of the QAPjP). Drill cuttings and development water will be containerized and stored on-property at the Hagen Farm decontamination facility.

2.3 GROUNDWATER FLOW DETERMINATION

2.3.1 Water Level Measurements

Static water level measurements will be taken at existing wells and staff gauges shown in Drawing 10006420-B2 during the well and staff gauge evaluation (refer to Section 2.1). Another round of static water levels will be taken at existing wells (excluding those that may, with U.S. EPA approval, be abandoned as a result of the well evaluation) and proposed wells and staff gauges that appear in Drawing 10006420-B2 during the baseline groundwater sampling round (refer to Section 2.4.2). Water level measurement methods are detailed in the FSP (Attachment A of the QAPjP).

In accordance with Section II.B.2.a(3) of the U.S. EPA Scope of Work (Appendix I of the Work Plan) and following start-up of the groundwater extraction system, water levels will be recorded at monitoring wells and staff gauges, monthly for the first year, every other month the second year, and quarterly thereafter until shutdown of the extraction system.

In addition, following shutdown of the extraction system, water level measurements will be collected concurrent with each groundwater sampling event.

Water level data will be evaluated by constructing water table maps and potentiometric surface maps with water level data collected from water table wells and piezometers. The vertical component of groundwater flow will be evaluated by preparing potentiometric contours in cross-section. Water level data collected during the RD/RA will be useful in evaluating the effectiveness of the extraction and treatment system in protecting private well supplies.

2.3.2 Hydraulic Conductivity Testing

Hydraulic conductivity testing of the new monitoring wells, except the pumping test extraction well and observation wells, will be performed. In situ single well hydraulic conductivity tests will be performed to assess hydraulic conductivity and groundwater flow rates. Data will be analyzed using the Bouwer and Rice method. Methods are detailed in Section 5.3.3.3 of the FSP (Attachment A of the QAPjP).

2.4 GROUNDWATER SAMPLING AND ANALYSIS

2.4.1 Groundwater Sampling Locations

The proposed groundwater monitoring program is intended to detect changes in the chemical concentrations of groundwater at and near the Hagen Farm property. It will include field and laboratory testing of samples collected from select new and existing monitoring wells on and off the Hagen Farm property. Analytical results obtained during the monitoring period will be used to meet the objectives stated in Section 1 of this plan. If during the performance of the groundwater monitoring program, additional information indicates that the program is inadequate to detect changes or the rate of change in the chemical concentrations in groundwater, or to determine the effectiveness of the groundwater extraction system, the U.S. EPA may modify the sampling location, frequency, duration, and/or the parameters analyzed for, by written notification to the Respondent.

The new wells and those to be retained from the existing monitoring system constitute the proposed groundwater monitoring program for the Hagen Farm GCOU. The program includes fifteen water table wells, twenty-two piezometers (assuming deep groundwater quality borings P36B, P38B, and P39B are instrumented with wells), and eleven private wells (Drawing 10006420-B2). Upgradient wells consist of water table wells MW1, MW20, and MW31.

Downgradient wells consist of the following:

Water Table Wells in Sand or Sand and Gravel		Piezometers in Unconsolidated Sediments		Piezometers in Bedrock	
MW22	MW16	P7B	P17B	P17C	P17D
MW26	MW7	P22B	P26B	P22C	P29C
MW29	MW23	P28B	P30B	P33B	P35B
MW34	MW27	P29B	P34B	P26C	P37B
MW32	MW30	P32B		P28C	P39B*
MW33	MW35			P30C	P38B*
				P36B*	

* Indicates proposed wells that may be installed during RD phase (refer to Section 2.2 of this document).

Existing and future monitoring wells and piezometers not included in the sampling list described above will be left in place and not permanently abandoned unless necessary. If well abandonment is necessary, U.S. EPA and WDNR will be notified. Wells will not be abandoned without U.S. EPA/WDNR approval.

The proposed monitoring locations were selected to detect changes in water quality near the water table, in the unconsolidated deposits between the water

table and bedrock, and in the bedrock. These well locations were selected based on a 3-dimensional evaluation of the aquifer along with the findings of the Remedial Investigation, to monitor groundwater quality upgradient, cross-gradient, and immediately downgradient of the Hagen Farm source area; and along a groundwater plume extending southeast from the property (Refer to Drawing 10006420-B2). The rationale for selecting the wells in and along the groundwater plume is that these wells will be sufficient to detect changes in chemical concentrations in the groundwater plume, and to monitor the effectiveness of the groundwater extraction and treatment system, as required in Section II.B.2.a of U.S. EPA's SOW. These wells have been selected to provide an indication of groundwater quality trends in and adjacent to the groundwater plume, thereby assessing the effectiveness of the extraction and treatment system in protecting private water supplies. Rationale for elimination of individual monitoring wells is provided in Table A3.

Private wells consist of wells located on the following properties. The private well identifications shown in parenthesis will be used for RD/RA sampling activities:

Sundby (PW01)
Sundby Sand and Gravel (PW03)
Fosdahl (PW05)
Van Deusen (PW07)
Stoughton Conservation Club (PW09)
Gjertson (PW11)
K-Way Insulation (PW02)
Gullickson (PW04)
Lee (PW06)
Quam (PW08)
Sagmoen (PW10)

Private well locations to be sampled are those listed in Section II.B.2.a(2) of the U.S. EPA Scope of Work for the Hagen Farm GCOU RD/RA (Appendix I of the Work Plan). Existing and proposed monitoring well and private well locations are shown on Drawing 10006420-B2.

2.4.2 Groundwater Sampling Frequency

The groundwater monitoring program will consist of sampling groundwater and measuring water levels in each of the monitoring wells, along with field and laboratory testing of the samples. Wells included in the groundwater monitoring program are those listed in the previous section, and are shown on Drawing 10006420-B2.

As outlined in Section II.B.2.a(3) of the U.S. EPA GCOU Scope of Work (Appendix I of the Work Plan), sampling will commence with a baseline round of sampling and water levels from the monitoring wells and private wells. The baseline sampling will occur following EPA approval of the GMP, but prior to the start-up of the groundwater extraction system.

Following start-up of the groundwater extraction system, monitoring wells will be sampled on a quarterly basis for a minimum of three years. After the first three years of monitoring, a proposal to reduce the frequency to semi-annual monitoring may be made, based on a determination that semi-annual sampling is sufficient to demonstrate the effectiveness of the groundwater extraction system.

Private wells will be sampled on an annual basis following start-up of the groundwater extraction system. Private well sampling will continue through the operation to at least 30 years after shutdown of the extraction system. At the end of 30 years, the U.S. EPA will determine the need for additional private well monitoring based on the accumulated data. Upon approval from the U.S. EPA, the Respondent may cease groundwater monitoring.

Following shutdown of the groundwater extraction system, monitoring wells will be sampled monthly for the first six months, and once every other month for the second six months. If the first year of monitoring indicates cleanup standards have been met, monitoring will be conducted on a quarterly basis for the next two years. Following three years of post shutdown monitoring, a proposal will be made to U.S EPA for semi-annual monitoring. Groundwater monitoring is required for a period of at least 30 years following shutdown of the groundwater extraction system.

Private well sampling will continue on an annual basis following shutdown of the groundwater extraction system. Private wells surrounding the site are located a sufficient distance from the groundwater plume to be outside the expected zone of direct influence by the extraction system. Based on information collected during the Hagen Farm RI (Warzyn 1991), average linear flow rates are less than 100 ft/yr. Therefore, as with private well monitoring during operation of the extraction system, annual monitoring during the post shutdown period will be a frequency sufficient to detect changes in water quality at the private well source.

Groundwater monitoring as described above will continue until it is demonstrated that cleanup standards have been continually satisfied at the "point of compliance" as described in Section II.B.2.b(15) of the U.S. EPA Scope of Work. The "point of compliance" will be at monitoring locations from the edge of the landfill cap and downgradient, for a period of 30 yrs following shutdown of the groundwater extraction system. The cleanup standards are those referenced in Section II.B.2.b(16) of the U.S. EPA Scope of Work: the Preventive Action Limit as set forth in Chapter NR 140, Wisconsin Administrative Code (WAC). Additional cleanup standards, consistent with the National Contingency Plan and Record of Decision, may be specified by the U.S. EPA for constituents detected during monitoring that lack numeric standards under Chapter NR 140, WAC.

As provided under Section II.B.2.b (16) of the U.S. EPA Scope of Work and Chapter NR 140.28, WAC, the U.S. EPA may establish an Alternative Concentration Limit (ACL) as a cleanup standard, if, based on site-specific monitoring data collected during the groundwater monitoring program, the U.S. EPA determines it is not technically and economically feasible to achieve PALs for a specific constituent.

Refer to the FSP (Attachment A to the QAPjP) for additional information pertaining to the sampling of groundwater.

2.4.3 Groundwater Sample Analysis

The groundwater samples collected as part of the groundwater monitoring program will be analyzed in the field and analytical laboratory for a variety of parameters in accordance with Section II.B.2.a.(4) of the U.S. EPA Scope of Work (Appendix I)

Field analyses to be performed during each sampling round described in the previous section will include pH, specific conductance, and temperature.

The "full laboratory analyses" to be performed during the baseline sampling round, annually for the first five years, and every three years thereafter, at the wells described in the previous section, will include:

- U.S. EPA Target Compound List (TCL) organics plus tetrahydrofuran (THF)
- U.S. EPA Target Analyte List (TAL) inorganics
- Groundwater Quality Indicator Parameters including: alkalinity, hardness, chloride, nitrate+nitrite-nitrogen, total dissolved solids, and chemical oxygen demand.

The "partial laboratory analyses" to be performed during the remaining sampling rounds described in the previous section, that will not undergo "full laboratory analyses", will consist of the constituents listed in Table 1 of the U.S. EPA Scope of Work (SOW): benzene, 1,1-dichloroethene, ethylbenzene, THF, toluene, xylenes, vinyl chloride, arsenic, barium, iron, lead, manganese, and mercury. For example, during the second year of monitoring following start-up of the groundwater extraction system, monitoring wells will be sampled on a quarterly basis. Therefore, during the second year the "full laboratory analyses" will be performed during the first quarter and the "partial laboratory analyses" will be performed during the remaining three quarters. Private wells, which are

scheduled to be monitored annually during the second year, will undergo "full laboratory analyses" only.

For additional information and details regarding sampling and analysis of groundwater, refer to the QAPjP and FSP located in Appendix G of this Hagen Farm GCOU RD Work Plan.

[mad-606-108]

3

REPORTS AND SUBMISSIONS

3.1 GROUNDWATER MONITORING REPORTS

A brief report transmitting results of groundwater monitoring activities will be submitted to the U.S. EPA within 60 days following each monitoring event. The report will include:

- Field data collected during sampling
- Copies of chain-of-custody forms
- Laboratory Quality Control Summary Sheets
- Data quality review narrative
- Water level measurements
- Comparison of analytical results to PALs and ESs listed in Chapter NR 140, WAC
- On an annual basis, groundwater quality trends will be evaluated and included in the groundwater monitoring report. The effectiveness of the monitoring system in protecting private water supplies will also be addressed.

3.2 PRIVATE WELL MONITORING REPORTS

Private well monitoring results will be incorporated into the groundwater monitoring report (monitoring wells) within 60 days of the sampling event during those rounds that include private well sampling. The information to be provided

for private wells will be the same as listed above for monitoring wells, with the exception of water level measurements (which are not taken at private wells).

In addition to the above, raw data results for the private well sampling will be submitted to U.S. EPA within three days following quality assurance/quality control of the data.

3.3 GROUNDWATER QUALITY BORING REPORTS

Because field activities during the groundwater quality boring program are dependent upon decisions based on the field GC analytical results, it is necessary to verbally communicate data to WMWI and U.S. EPA project managers. The following data will be verbally reported from the field as it becomes available:

- GC analytical results
- Soil and rock descriptions
- Water level measurements
- Borehole location, depth, and estimated elevation at depth

A brief letter transmitting these results will also be submitted to the U.S. EPA project manager within five working days following verbal communication.

[mad-606-108]

4

SEQUENCE OF WORK

The proposed sequence of work for implementation of the GMP is shown below, reflecting the requirements of the U.S. EPA SOW. Activities associated with the GMP will begin within 30 days following U.S. EPA approval of the Work Plan, including the QAPjP.

1. Evaluation of existing monitoring wells and staff gauges, and collection of water level measurements. Solicit bids from drilling subcontractors.

2. Install groundwater quality borings and monitoring wells with concurrence of WMWI and approval of U.S. EPA.

3. New monitoring well development.

4. Submittal of Groundwater Quality Boring Report to U.S. EPA.

5. Baseline groundwater sampling and water level measurements from new and existing monitoring well and private wells.

6. Laboratory analyses of baseline samples for the "full laboratory analyses" parameters.

7. Quality assurance/quality control (QA/QC) review, interpretation of analytical data, and preparation of groundwater monitoring report and private well monitoring report.

8. Submittal of private well raw data to U.S. EPA within 3 days of QA/QC review.

9. Submittal of groundwater monitoring report to U.S. EPA presenting monitoring well results.

10. Submittal of private well monitoring report to U.S. EPA presenting private well results.

[mad-606-108]

5

REFERENCES

U.S. Environmental Protection Agency, 1988. *Draft Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (OSWER Directive 9355.3-01)*, Office of Emergency and Remedial Response, Washington, D.C.

U.S. Environmental Protection Agency, 1992. *Scope of Work for the Remedial Design and Remedial Action Work Plan the Hagen Farm Site, Groundwater Control Operable Unit.* Stoughton, Wisconsin. November 1992.

Waste Management Incorporated, 1990. *Well Construction and Development.*

Warzyn Inc., 1991. *Final Remedial Investigation Report, Hagen Farm RI/FS, Town of Dunkirk, Dane County, Wisconsin.* Volume 1 of 4. Project No. 13452.

JEM/cas/JDD/JGV/GEA/KEB/RJK/KJQ
[mad-606-108]
10006420/184

TABLES

TABLE A1

Proposed Borehole and Well Construction Details
Remedial Design Work Plan
Hagen Farm

Well I.D.(4)	Estimated Total Borehole Depth (ft)	Estimated Borehole Diameter (in.)	Estimated Total Well Depth (ft)	Estimated Screen Length (ft)	Screen Material(1)	Estimated Riser Pipe Length(2) (ft)	Riser Pipe Material	Estimated Ground Surface Elevation (MSL)	Sampling While Drilling(5)
RW02	120.0	12	120.0	30	6 in. #304 Continuous Wrap S.S.	62.5	6 in. Black Steel	860	—
OB7M	92.5	6	92.5	5	2 in. Sch 40 PVC Slotted	90.0	2 in. Sch 40 PVC	860	—
(3) OB8D	140.0	6	140.0	5	2 in. Sch 80 PVC Slotted	137.5	2 in. Sch 80 PVC	860	SS, RC, GW
OB8S	40.0	6	40.0	5	2 in. Sch 40 PVC Slotted	37.5	2 in. Sch 40 PVC	860	—
OB8M	92.5	6	92.5	5	2 in. Sch 40 PVC Slotted	90.0	2 in. Sch 40 PVC	860	SS
OB9M	92.5	6	92.5	5	2 in. Sch 40 PVC Slotted	90.0	2 in. Sch 40 PVC	860	SS
OB10M	92.5	6	92.5	5	2 in. Sch 40 PVC Slotted	90.0	2 in. Sch 40 PVC	860	SS
OB11M	92.5	6	92.5	5	2 in. Sch 40 PVC Slotted	90.0	2 in. Sch 40 PVC	860	SS
OB12M	92.5	6	92.5	5	2 in. Sch 40 PVC Slotted	90.0	2 in. Sch 40 PVC	860	SS
MW36	15.0	6	15.0	10	2 in. Sch 40 PVC Slotted	7.5	2 in. Sch 40 PVC	855	—
(3) P36B	155.0	6	130.0	5	2 in. Sch 80 PVC Slotted	127.5	2 in. Sch 80 PVC	855	GW, SS
(3) P38B	155.0	6	130.0	5	2 in. Sch 80 PVC Slotted	127.5	2 in. Sch 80 PVC	860	GW, SS
(3) P39B	155.0	6	130.0	5	2 in. Sch 80 PVC Slotted	127.5	2 in. Sch 80 PVC	861	GW, RC, SS
MW37	15.0	6	15.0	10	2 in. Sch 40 PVC Slotted	7.5	2 in. Sch 80 PVC	861	—
MW38	15.0	6	15.0	10	2 in. Sch 40 PVC Slotted	7.5	2 in. Sch 80 PVC	877	—
MW39	15.0	6	15.0	10	2 in. Sch 40 PVC Slotted	7.5	2 in. Sch 80 PVC	861	—
(3) P37B	140.0	6	120.0	5	2 in. Sch 80 PVC Slotted	117.5	2 in. Sch 80 PVC	860	GW, SS
MW35	15.0	6	15.0	10	2 in. Sch 40 PVC Slotted	7.5	2 in. Sch 40 PVC	855	—
P35B	80.0	6	80.0	5	2 in. Sch 40 PVC Slotted	77.5	2 in. Sch 40 PVC	855	—

FOOTNOTES:

(1) All screens will be 0.010 in. slot size.

(2) Includes a stick-up of 2.5 ft.

(3) Groundwater quality boring.

(4) S = Bottom of Shallow Well (screen to be set approximately 20 ft above top of extraction well screen)
M = Intermediate Well (screen to be set midway between top and bottom of extration well screen)
D = Deep Well (top of screen to be set approximately 20 ft below the bottom of the extraction well screen)

(5) SS = Split Spoon RC = Rock Core GW = Groundwater Sample

JEM/jlv/TAPB
[Hagen\Table A-1]
10006420

TABLE A2

Well Inventory
Remedial Design Work Plan
Hagen Farm

WELL NO.		WELL MATERIAL	DATE INSTALLED	DRILLED BY	LOG AVAILABLE?	TOP OF CASING ELEVATION (FT)		GROUND ELEV. (MSL)	BOREHOLE DEPTH (FT)
8401		(2)	4-84	USGS	No (1)	885.34	(12)	883.15	30
8402		(2)	4-84	USGS	No (1)	893.55		893.05	42
8403		(2)	4-84	USGS	No (1)	887.27	(12)	883.75	39
8404		(2)	4-84	USGS	No (1)	890.59	(12)	887.95	41
8405		1.5" PVC	4-84	USGS	No (1)	864.14		863.95	15
8406		(2)	4-84	USGS	No (1)	866.01	(12)	863.25	16
8407		(2)	4-84	USGS	No (1)	865.34	(12)	863.75	20
8408		(2)	4-84	USGS	No (1)	867.14	(12)	865.45	15
8409		(2)	4-84	USGS	No (1)	871.08	(12)	869.35	15
8410		(2)	4-84	USGS	No (1)	866.90	(12)	864.65	15
8411		(2)	4-84	USGS	No (1)	–		–	20
8412		(2)	4-84	USGS	No (1)	–		–	16
8413		(2)	4-84	USGS	No (1)	883.46	(12)	883.25	28
LH1 (ESB3)		(6)	9-14-88	Warzyn	YES	879.33		877.10	16
MW1	(10)	(1)	7-27-82	Warzyn	YES	893.82		891.45	40
MW4		(1)	7-20-82	Warzyn	YES	876.88		873.75	20
MW7	(10)	(1)	7-21-82	Warzyn	YES	877.36		875.85	70
MW9		(1)	8-2-82	Warzyn	YES	877.84		876.60	30
MW12 (B12)		(1)	7-29-82	Warzyn	YES	882.21		881.10	45
MW13 (B13)		(4)	8-17-88	Warzyn	YES	874.25		871.60	20.1
MW14 (B14)		(4)	8-29-88	Warzyn	YES	883.40		880.60	28.5
MW15 (B15)		(4)	8-28-88	Warzyn	YES	903.30		901.10	48.4
MW16 (B16)		(4)	8-4-88	Warzyn	YES	884.01		881.80	31.4
MW17 (B17)		(4)	9-1-88	Warzyn	YES	865.77		863.40	18.5
MW18 (B18)		(4)	8-26-88	Warzyn	YES	862.79		860.70	18.7
MW19 (B19)		(4)	8-23-88	Warzyn	YES	862.21		859.80	18.4
MW20 (B20)		(4)	8-5-88	Warzyn	YES	888.26		885.70	31.1
MW21 (B21)		(4)	8-9-88	Warzyn	YES	879.51		876.83	27.1
MW22 (B22)	(10)	(4)	9-20-88	Warzyn	YES	878.31		876.30	28
MW23 (B23)	(10)	(4)	9-21-88	Warzyn	YES	887.46		884.40	35
MW24 (B24)		(4)	9-22-88	Warzyn	YES	874.97		873.30	25
MW25 (B25)		(4)	8-15-89	Warzyn	YES	862.41		859.70	15.50
MW26 (B26)	(10)	(7)	7-14-89	Warzyn	YES	883.87		881.70	34.00
MW27 (B27)	(10)	(4)	7-26-89	Warzyn	YES	872.27		870.30	25.00
MW28 (B28)		(4)	7-31-89	Warzyn	YES	864.76		862.00	17.00
MW29 (B29)	(10)	(4)	8-15-89	Warzyn	YES	878.23		875.60	29.00
MW30 (B30)	(10)	(4)	7-21-89	Warzyn	YES	869.26		866.40	25.00
MW31 (B31)	(10)	(9)	8-18-89	Warzyn	YES	907.68		905.00	55.00
MW32 (B32)	(10)	(7)	6-13-90	Warzyn	YES	860.75		858.10	20.50
MW33 (B33)		(7)	4-5-90	Warzyn	YES	866.55		864.00	17.30
MW34 (B34)	(10)	(4)	3-13-91	Warzyn	YES	859.03		856.90	15.00
OB1		(5)	10-30-90	Warzyn	YES	873.57		871.50	45.00
OB2		(4)	10-30-90	Warzyn	YES	867.39		865.20	39.00
OB3		(4)	10-31-90	Warzyn	YES	866.15		864.00	45.00

TABLE A2

WELL NO.		WELL MATERIAL	DATE INSTALLED	DRILLED BY	LOG AVAILABLE?	TOP OF CASING ELEVATION (FT)		GROUND ELEV. (MSL)	BOREHOLE DEPTH (FT)
OB4		(4)	11-6-90	Warzyn	YES	865.97		863.90	40.00
OB5		(4)	11-7-90	Warzyn	YES	866.43		864.40	38.00
OB6		(4)	11-8-90	Warzyn	YES	868.01		865.90	38.00
P6A		(1)	7-28-82	Warzyn	YES	882.16		880.45	30
P6B		(1)	7-28-82	Warzyn	YES	882.57		880.45	57.5
P7B	(10)	(5)	9-8-88	Warzyn	YES	877.65		875.90	54.4
P8A		(1)	7-22-82	Warzyn	YES	871.08		868.95	30
P8B		(1)	7-26-82	Warzyn	YES	870.93		868.95	50
P12B (B12B)		(5)	9-12-88	Warzyn	YES	881.79		879.80	58.5
P14B (B14B)		(6)	8-31-88	Warzyn	YES	883.13		880.80	61.5
P17B (B17B)	(10)	(5)	9-7-88	Warzyn	YES	865.35		863.40	51.5
P17C (B17C)	(10)	(6)	7-12-89	Warzyn	YES	865.31		863.50	63.00
P17D (B17D)	(10)	(6)	4-24-90	Warzyn	YES	865.35		863.20	93.00
P22B (B22B)	(10)	(5)	8-1-89	Warzyn	YES	878.55		876.40	50.00
P22C (B22CR)		(6)	4-19-90	Warzyn	YES	878.81		876.30	99.00
P25B (B25B)		(5)	8-15-89	Warzyn	YES	862.77		859.70	42.00
P26B (B26B)	(10)	(5)	7-20-89	Warzyn	YES	883.29		881.90	68.75
P26C (B26C)	(10)	(6)	5-2-90	Warzyn	YES	883.83		881.80	90.00
P27B (B27B)		(5)	7-26-89	Warzyn	YES	872.02		869.90	50.00
P28B (B28B)	(10)	(5)	7-28-89	Warzyn	YES	863.84		861.70	45.00
P28C (B28C)	(10)	(6)	5-18-90	Warzyn	YES	863.22		861.30	105.60
P29B (B29B)	(10)	(5)	8-15-89	Warzyn	YES	878.43		875.80	58.50
P29C (B29C)	(10)	(6)	5-25-90	Warzyn	YES	877.77		875.40	91.70
P30B (B30B)	(10)	(5)	7-24-89	Warzyn	YES	867.96		866.40	46.40
P30C (B30C)	(10)	(6)	5-9-90	Warzyn	YES	867.01		866.10	98.00
P32B (B32B)	(10)	(6)	6-11-90	Warzyn	YES	860.47		857.70	94.50
P33B (B33B)		(6)	6-18-90	Warzyn	YES	866.49		864.10	69.50
P34B (B34B)	(10)	(6)	3-13-91	Warzyn	YES	859.36		856.60	93.00
QW1		(3)	8-84	USGS	No (1)	897.10	(13)	892.55	47
QW2		(3)	8-84	USGS	No (1)	888.15		887.35	42
QW3		(3)	8-84	USGS	No (1)	–		–	24
QW4		(3)	8-84	USGS	No (1)	863.95	(12)	862.95	21
QW5		(3)	8-84	USGS	No (1)	879.61		878.95	31
QW6		(3)	8-84	USGS	No (1)	871.60		868.15	21
RW1		(8)	10-31-90	Warzyn	YES	866.97		864.60	37.9
SCW1		(7)	11-21-88	Warzyn	YES	878.88		876.90	25.5
SCW2		(7)	11-23-88	Warzyn	YES	882.78		880.60	26
SCW3		(7)	11-22-88	Warzyn	YES	875.93		873.60	22.5
SCW4		(7)	11-22-88	Warzyn	YES	879.58		877.50	28
SCW5		(7)	11-21-88	Warzyn	YES	879.64		877.50	24.5

TABLE A2

WELL NO.	WELL STICKUP (FT)	WELL DEPTH (FT)	SCREENED INTERVAL (DEPTH IN FT)		SCREENED INTERVAL (MSL)		SEAL INTERVAL (DEPTH IN FT)		SEAL INTERVAL (MSL)		AQUIFER MONITORED (UNIFIED SOIL CLASSIFICATION SYMBOL)	ADDITIONAL COMMENTS
8401	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8402	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8403	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8404	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8405	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8406	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8407	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8408	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8409	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8410	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8411	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8412	–	–	–	–	–	–	–	–	–	–	–	Abandoned
8413	–	–	–	–	–	–	–	–	–	–	–	Abandoned
LH1 (ESB3)	2.2	13.0	8.0	13.0	869.1	864.1	0.0	5.0	877.1	872.1	FILL	
MW1	2.4	38.4	33.9	38.4	857.6	853.1	0.0	3.0	891.5	888.5	SAND (SM)	
MW4	3.1	18.0	13.5	18.0	860.3	855.8	0.0	3.0	873.8	870.8	SAND (SM)	Abandoned
MW7	1.5	24.0	19.5	24.0	856.4	851.9	0.0	3.0	875.9	872.9	SAND (SM)	
MW9	1.2	30.0	25.5	30.0	851.1	846.6	0.0	3.0	876.6	873.6	SAND (SM)	Abandoned
MW12 (B12)	1.1	28.0	23.5	28.0	857.6	853.1	0.0	3.0	881.1	878.1	SAND (SM)	Abandoned
MW13 (B13)	2.6	20.1	9.2	20.1	862.4	851.5	0.0	7.7	871.6	863.9	SAND (SP,SP-SM)	
MW14 (B14)	2.8	28.1	17.2	28.1	863.4	852.5	0.0	15.0	880.6	865.6	SAND (SP-SW)	
MW15 (B15)	2.2	48.4	37.5	48.4	863.6	852.7	0.0	35.5	901.1	865.6	SAND (SM)	
MW16 (B16)	2.2	31.4	20.5	31.4	861.3	850.4	0.0	18.1	881.8	863.7	SAND (SM-SP)	
MW17 (B17)	2.4	18.2	7.3	18.2	856.1	845.2	0.0	5.3	863.4	858.1	SAND AND GRAVEL (SP,GP,GM)	Abandoned
MW18 (B18)	2.1	18.7	7.8	18.7	852.9	842.0	0.0	5.7	860.7	855.0	SAND AND GRAVEL (GP-GM)	
MW19 (B19)	2.4	18.4	7.5	18.4	852.3	841.4	0.0	5.5	859.8	854.3	LEAN CLAY (CL)/SAND AND GRAVEL (SP-GP)	
MW20 (B20)	2.6	31.1	20.2	31.1	865.5	854.6	0.0	17.7	885.7	868.0	SAND (SP)	
MW21 (B21)	2.7	27.1	16.2	27.1	860.6	849.7	0.0	14.3	876.8	862.5	SAND (SP,SP-SM)	Abandoned
MW22 (B22)	2.0	25.2	14.2	25.2	862.1	851.1	0.0	10.0	876.3	866.3	SAND (SP-SM)	
MW23 (B23)	3.1	34.0	23.1	34.0	861.3	850.4	0.0	19.7	884.4	864.7	SAND AND GRAVEL (SP-SM,GP-GM)	
MW24 (B24)	1.7	24.0	13.1	24.0	860.2	849.3	0.0	11.0	873.3	862.3	SAND (SP-SM)	Abandoned
MW25 (B25)	2.7	14.10	3.90	14.10	855.8	7.0	1.0	2.8	858.7	856.9	SAND (SP)	
MW26 (B26)	2.2	22.70	33.00	22.70	848.7	859.0	15.6	18.5	866.1	863.2	SAND (SM-GM)	
MW27 (B27)	2.0	23.40	13.40	23.40	856.9	846.9	7.0	10.0	863.3	860.3	SAND (SP-GP)	
MW28 (B28)	2.8	15.30	3.50	15.30	858.5	846.7	1.5	2.8	860.5	859.2	SAND (SP-GP)	
MW29 (B29)	2.6	28.00	16.20	28.00	859.4	847.6	8.5	12.4	867.1	863.2	SAND (SP-GP)	
MW30 (B30)	2.9	19.60	9.00	19.60	857.4	846.8	5.2	8.2	861.2	858.2	SAND (SP)	
MW31 (B31)	2.7	53.10	35.70	53.10	869.3	851.9	26.3	29.5	878.7	875.5	SAND (SM)	
MW32 (B32)	2.6	19.00	8.80	19.00	849.3	839.1	7.6	5.9	850.5	852.2	SAND (ML-SP)	
MW33 (B33)	2.5	17.30	7.50	17.30	856.5	846.7	2.0	5.0	862.0	859.0	CLAY (SC)	
MW34 (B34)	2.1	14.60	4.60	14.60	852.3	842.3	0.0	2.9	856.9	854.0	SAND (SP)	
OB1	2.1	35.70	29.15	35.70	842.4	835.8	26.6	24.7	844.9	846.8	SAND (SP)	
OB2	2.2	30.55	20.05	30.55	845.2	834.7	35.0	39.0	830.2	826.2	SAND AND GRAVEL (SP)	
OB3	2.1	32.80	22.30	32.80	841.7	831.2	22.3	32.8	841.7	831.2	SAND (SP-SM)	

TABLE A2

WELL NO.	WELL STICKUP (FT)	WELL DEPTH (FT)	SCREENED INTERVAL (DEPTH IN FT)		SCREENED INTERVAL (MSL)		SEAL INTERVAL (DEPTH IN FT)		SEAL INTERVAL (MSL)		AQUIFER MONITORED (UNIFIED SOIL CLASSIFICATION SYMBOL)	ADDITIONAL COMMENTS
OB4	2.1	32.60	22.10	32.60	841.8	831.3	34.6	40.0	829.3	823.9	SAND (SP)	
OB5	2.0	32.35	21.90	32.35	842.5	832.1	33.6	38.0	830.8	826.4	SAND (SP)	
OB6	2.1	31.80	21.25	31.80	844.7	834.1	33.0	38.0	832.9	827.9	SAND (SP)	
P6A	1.7	30.0	25.5	30.0	855.0	850.5	47.0	50.0	833.5	830.5	SAND (SM)	Abandoned
P6B	2.1	55.0	50.5	55.0	830.0	825.5	0.0	3.0	880.5	877.5	SANDSTONE	Abandoned
P7B	1.8	52.7	47.2	52.7	828.7	823.2	0.0	45.7	875.9	830.2	SILT (ML)	
P8A	2.1	21.5	17.0	21.5	852.0	847.5	0.0	3.0	869.0	866.0	SAND & GRAVEL (GP-GM)/SAND (SM)	
P8B	2.0	45.5	41.0	45.5	828.0	823.5	38.0	40.0	831.0	829.0	SAND (SM)	
P12B (B12B)	2.0	57.6	52.1	57.6	827.7	822.2	0.0	57.6	879.8	822.2	SAND (SM)	Abandoned
P14B (B14B)	2.3	61.5	56.0	61.5	824.8	819.3	0.0	51.0	880.8	829.8	SAND (SP)	
P17B (B17B)	2.0	51.5	46.0	51.5	817.4	811.9	0.0	43.6	863.4	819.8	SAND AND GRAVEL (GP-GM);WEATHERED BEDROCK	
P17C (B17C)	1.8	61.60	55.40	61.60	808.1	801.9	50.0	52.0	813.5	811.5	SANDSTONE	
P17D (B17D)	2.1	91.10	86.10	91.10	777.1	772.1	79.0	81.0	784.2	782.2	SANDSTONE	
P22B (B22B)	2.1	49.10	42.90	49.10	833.5	827.3	33.8	35.7	842.6	840.7	SAND (SM)	
P22C (B22CR)	2.5	89.40	84.10	89.40	792.2	786.9	75.7	78.7	800.6	797.6	SANDSTONE	
P25B (B25B)	3.1	41.10	34.90	41.10	824.8	818.6	26.5	28.6	833.2	831.1	SAND (SM)	
P26B (B26B)	1.4	48.50	42.30	48.50	839.6	833.4	35.4	37.1	846.5	844.8	SAND (SM)	
P26C (B26C)	2.0	84.50	79.20	84.50	802.6	797.3	71.9	74.9	809.9	806.9	SILTSTONE	
P27B (B27B)	2.1	49.00	42.80	49.00	827.1	820.9	0.0	1.5	869.9	868.4	SAND (SP)	
P28B (B28B)	2.1	43.90	37.70	43.90	824.0	817.8	22.2	29.9	839.5	831.8	SAND (SP)	
P28C (B28C)	1.9	101.10	95.80	101.10	765.5	760.2	90.3	93.6	771.0	767.7	SANDSTONE	
P29B (B29B)	2.6	57.00	50.80	57.00	825.0	818.8	41.8	44.8	834.0	831.0	SAND (SM)	
P29C (B29C)	2.4	84.00	78.80	84.00	796.6	791.4	72.3	74.5	803.1	800.9	CHERT	
P30B (B30B)	1.6	45.00	38.80	45.00	827.6	821.4	0.0	1.0	866.4	865.4	SAND (SM)	
P30C (B30C)	0.9	97.50	92.00	97.50	774.1	768.6	86.0	88.0	780.1	778.1	SANDSTONE	
P32B (B32B)	2.8	75.20	70.10	75.20	787.6	782.5	64.6	75.2	793.1	782.5	SANDSTONE	
P33B (B33B)	2.4	64.70	59.50	64.70	804.6	799.4	49.0	56.2	815.1	807.9	SANDSTONE	
P34B (B34B)	2.8	79.50	74.70	79.50	781.9	777.1	70.0	72.5	786.6	784.1	GRAVEL (GM)	
QW1	–	–	–	–	–	–	–	–	–	–	–	Abandoned
QW2	–	–	–	–	–	–	–	–	–	–	–	Abandoned
QW3	–	–	–	–	–	–	–	–	–	–	–	Abandoned
QW4	–	–	–	–	–	–	–	–	–	–	–	Abandoned
QW5	–	–	–	–	–	–	–	–	–	–	–	Abandoned
QW6	–	–	–	–	–	–	–	–	–	–	–	Abandoned
RW1	2.4	35.1	19.6	35.1	845.0	829.5	35.8	37.9	828.8	826.7	SAND (SP)/SANDSTONE	
SCW1	2.0	25.5	15.5	25.5	861.4	851.4	0.0	13.6	876.9	863.3	SAND (SM)	Abandoned
SCW2	2.2	26.0	16.0	26.0	864.6	854.6	0.0	13.8	880.6	866.8	SAND (SM)	Abandoned
SCW3	2.3	21.5	11.5	21.5	862.1	852.1	0.0	9.0	873.6	864.6	SAND AND GRAVEL (SC)/SAND (SP)	Abandoned
SCW4	2.1	27.0	17.0	27.0	860.5	850.5	0.0	14.8	877.5	862.7	SAND AND GRAVEL (SP-GP)	Abandoned
SCW5	2.1	24.5	14.5	24.5	863.0	853.0	0.0	12.5	877.5	865.0	SAND (SP-SM)	Abandoned

TABLE A2

FOOTNOTES:

(1) 4.5 ft long 2 in. I.D. stainless steel well point except wells P-6B, P-8B which have 4.5 ft long galvanized well stand pipe.

(2) 9 ft long 1 in. I.D. galvanized steel and brass screen; 1 in. I.D. black steel well stand pipe.

(3) 3 ft long 2 in. I.D. stainless steel well screen; 2 in. I.D. galvanized steel well stand pipe.

(4) 10.9 ft long 2 in. I.D. Sch 40 PVC screen, continuous wrap; 2 in. I.D. Sch 40 PVC riser.

(5) 5.5 ft 2 in. I.D. Sch 40 PVC screen, continuous wrap; 2 in. I.D. Sch 40 PVC riser.

(6) 5.5 ft 2 in. I.D. Sch 80 PVC screen; 2 in. I.D. Sch 80 PVC riser.

(7) 10 ft long 2 in. I.D. Sch 80 PVC screen; 2 in. I.D. Sch 80 PVC riser.

(8) 15 ft long 6 in. I.D. stainless steel well screen, continuous wrap; 6" I.D. black PE riser.

(9) 15 ft long 2 in. I.D. Sch 40 PVC screen, continuous wrap; 2 in. I.D. Sch 40 PVC riser.

(10) These wells would be sampled as part of the Alternative Groundwater Monitoring Plan.

(11) USGS borings were drilled using hollow stem augers and split spoon soil samples were not obtained. Total depth of well, screened interval and seal interval were not specified and are therefore not included in this table.

(12) Top of casing elevations are top of well casing except wells with footnote (4), which are top of well cap.

(13) QW-1 resurveyed after well was repaired. Elevation measured to top of lower lock plate.

NOTES:

1. Refer to Table A-1 for a list of the proposed groundwater monitoring wells and boreholes.

2. All elevations of wells installed before 1988 have been corrected by a factor of +0.75 ft based on the resurveying of wells MW-9 and MW-12 by Kapur and Assoc., on 7-19-88.

JEM/jlw/KGV/DD/KEB
[Hagen/TableA-2.xls]
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TABLE A3

Rationale for Not Sampling Select Groundwater Wells
Remedial Design Work Plan
Hagen Farm

WELL NO.	RATIONALE FOR NOT SAMPLING
8401	Abandoned during waste consolidation.
8402	Abandoned during waste consolidation.
8403	Abandoned during waste consolidation.
8404	Abandoned during waste consolidation.
8405	Abandoned during waste consolidation.
8406	Abandoned during waste consolidation.
8407	Abandoned during waste consolidation.
8408	Abandoned during waste consolidation.
8409	Abandoned during waste consolidation.
8410	Abandoned during waste consolidation.
8411	Abandoned during waste consolidation.
8412	Abandoned during waste consolidation.
8413	Abandoned during waste consolidation.
LH1 (ESB3)	Abandoned during waste consolidation.
MW4	Abandoned during waste consolidation.
MW9	Abandoned during waste consolidation.
MW12 (B12)	Abandoned during waste consolidation.
MW13 (B13)	Intended Use: Water Level Measurements. Also, this well is located approximately 400 ft up-gradient and 600 ft side-gradient of source disposal area A. Previous sampling showed no detections of the compounds listed in Table 1 of the EPA SOW.
MW14 (B14)	Intended Use: Water Level Measurements. This well is located approximately 400 ft up-gradient of source disposal area A and previous sampling showed no detections of the compounds listed in Table 1 of the EPA SOW.
MW15 (B15)	Intended Use: Water Level Measurements. This well is located approximately 400 ft side-gradient of source disposal area A and previous sampling showed no detections of the compounds listed in Table 1 of the EPA SOW.

TABLE A3

WELL NO.	RATIONALE FOR NOT SAMPLING
MW16 (B16)	Intended Use: Water Level Measurements. This well is located approximately 400 ft side-gradient of source disposal area A. Previous sampling showed no detections of the compounds listed in Table 1 of the EPA SOW.
MW17 (B17)	Abandoned during waste consolidation.
MW18 (B18)	Intended Use: Water Level Measurements. This well is located side-gradient to the horizontal extent of the groundwater plume. Previous sampling showed no detections of the compounds listed in Table 1 of the EPA SOW. In addition, monitoring well nest 30 provides sufficient coverage in this area to detect changes in groundwater quality and provide indications of eastward expansion of the groundwater plume.
MW19 (B19)	Intened Use: Water Level Measurements. This well is located approximately 600 ft side-gradient of source disposal area A and previous sampling showed no detections of the compounds listed in Table 1 of the EPA SOW.
MW20 (B20)	Intended Use: Water Level Measurements. This well is located approximately 200 ft up-gradient of source disposal area A and previous sampling showed no detections of the compounds listed in Table 1 of the EPA SOW.
MW21 (B21)	Abandoned during waste consolidation.
MW24 (B24)	Abandoned during waste consolidation.
MW25 (B25)	Intended Use: Water Level Measurements. This well is located approximately 600 ft side-gradient of source disposal area A and previous sampling showed no detections of the compounds listed in Table 1 of the EPA SOW.
MW28 (B28)	Intended Use: Water Level Measurements. This well is located in the center of the plume. Existing monitoring well nests 17, 26, 27, 29, 30, and 32 surround MW28 and provide sufficient coverage in the plume.
MW33 (B33)	Intended Use: Water Level Measurements. This well is located side-gradient of the groundwater plume, and there were no detections of the compounds listed in Table 1 of the EPA SOW. Monitoring well nests 17, 22, and 30 surround this well in the groundwater plume, and provide sufficient coverage in this area to detect changes in groundwater quality.
MW36	Intended Use: Water Level Measurements. This proposed water table well is located along the potential western extent of the groundwater plume. Previous results at sampling locations this far down-gradient of the source indicate the plume extends deeper within the aquifer and is not at the water table.
MW37	Intended Use: Water Level Measurements. This proposed water table well is located along the potential western extent of the groundwater plume. Previous results at sampling locations this far down-gradient of the source indicate the plume extends deeper within the aquifer and is not at the water table.

TABLE A3

WELL NO.	RATIONALE FOR NOT SAMPLING
MW38	Intended Use: Water Level Measurements. This proposed water table well is located along the potential western extent of the groundwater plume. Previous results at sampling locations this far down-gradient of the source indicate the plume extends deeper within the aquifer and is not at the water table.
MW39	Intended Use: Water Level Measurements. This proposed water table well is located along the potential western extent of the groundwater plume. Previous results at sampling locations this far down-gradient of the source indicate the plume extends deeper within the aquifer and is not at the water table.
OB01	Intended Use: On-property pumping test observation point.
OB02	Intended Use: On-property pumping test observation point.
OB03	Intended Use: On-property pumping test observation point.
OB04	Intended Use: On-property pumping test observation point.
OB05	Intended Use: On-property pumping test observation point.
OB06	Intended Use: On-property pumping test observation point.
OB07M	Intended Use: Off-property pumping test observation point.
OB08S	Intended Use: Off-property pumping test observation point.
OB08M	Intended Use: Off-property pumping test observation point.
OB08D	Intended Use: Off-property pumping test observation point.
OB09M	Intended Use: Off-property pumping test observation point.
OB10M	Intended Use: Off-property pumping test observation point.
OB11M	Intended Use: Off-property pumping test observation point.
OB12M	Intended Use: Off-property pumping test observation point.
P6A	Abandoned during waste consolidation.
P6B	Abandoned during waste consolidation.
P8A	Monitoring well nest 7 (located north of nest 8) and 22 (located south of nest 8) bracket this well and will sufficiently detect changes in groundwater quality in this area.
P8B	Monitoring well nest 7 (located north of nest 8) and 22 (located south of nest 8) bracket this well and will sufficiently detect changes in groundwater quality in this area.
P12B (B12B)	Abandoned during waste consolidation.
P14B (B14B)	Intended Use: Water Level Measurements. This well is located approximately 400 ft up-gradient and 600 ft side-gradient of source disposal area A.
P22C (B22CR)	Monitoring wells MW22 and P22B are screened in the shallow aquifer and will sufficiently detect changes in groundwater quality and identify potential vertical extension of the plume in this area.

TABLE A3

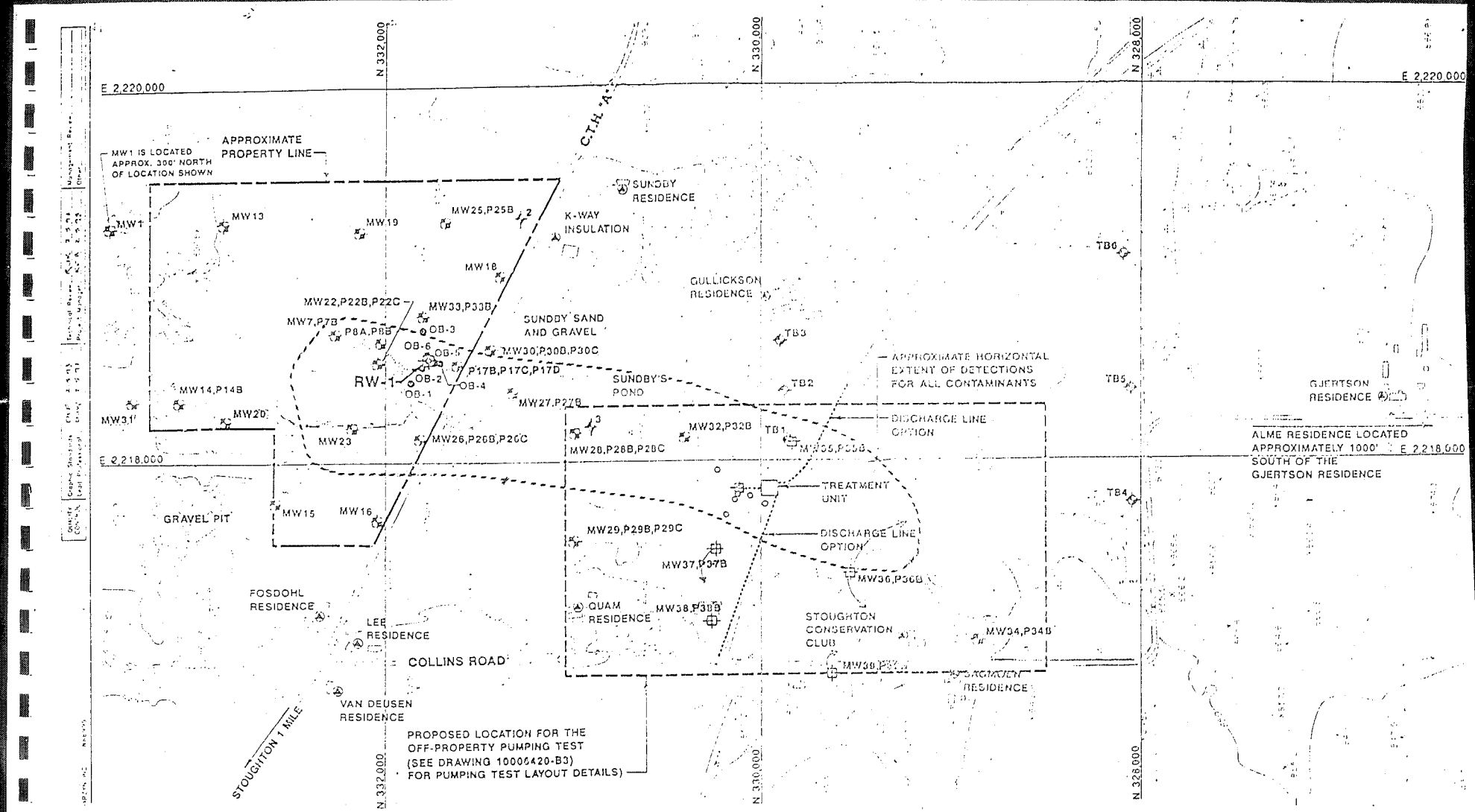
WELL NO.	RATIONALE FOR NOT SAMPLING
P25B (B25B)	Intended Use: Water Level Measurements. This well is located approximately 400 ft up-gradient and 600 ft side-gradient of source disposal area A.
P27B (B27B)	This well is screened in the aquifer beneath the groundwater plume. Well nests 17, 26, 30, and 32 surround this well and monitor both the shallow and deep portions of the aquifer, and therefore will provide sufficient coverage for this area.
P33B (B33B)	Intended Use: Water Level Measurements. This well is located side-gradient of the plume, and previous sampling indicated no detections of the compounds listed in Table 1 of the EPA SOW. In addition, well nest 30 will sufficiently detect changes in groundwater quality in this area and detect potential eastward extension of the groundwater plume.
QW1	Abandoned during waste consolidation.
QW2	Abandoned during waste consolidation.
QW3	Abandoned during waste consolidation.
QW4	Abandoned during waste consolidation.
QW5	Abandoned during waste consolidation.
QW6	Abandoned during waste consolidation.
SCW1	Abandoned during waste consolidation.
SCW2	Abandoned during waste consolidation.
SCW3	Abandoned during waste consolidation.
SCW4	Abandoned during waste consolidation.
SCW5	Abandoned during waste consolidation.

NOTES:

1. Refer to Drawing 10006420-B2 for well locations.
2. Well number label in parentheses refers to boring log label.

JEM/jlw/JDD
[Hagen/TableA-3.xls]
10006420
2/19/93

DRAWINGS


E 2,220,000
N 332,000
N 330,000
N 328,000
E 2,218,000
C.T.H. "A"
APPROXIMATE PROPERTY LINE
MW1 IS LOCATED APPROX. 300' NORTH OF LOCATION SHOWN
SUNDBY RESIDENCE
K-WAY INSULATION
GULLICKSON RESIDENCE
SUNDBY SAND AND GRAVEL
SUNDBY'S POND
APPROXIMATE HORIZONTAL EXTENT OF DETECTIONS FOR ALL CONTAMINANTS
DISCHARGE LINE OPTION
TREATMENT UNIT
DISCHARGE LINE OPTION
GJERTSON RESIDENCE
ALME RESIDENCE LOCATED APPROXIMATELY 1000' SOUTH OF THE GJERTSON RESIDENCE
GRAVEL PIT
FOSDOHL RESIDENCE
LEE RESIDENCE
QUAM RESIDENCE
STOUGHTON CONSERVATION CLUB
COLLINS ROAD
VAN DEUSEN RESIDENCE
STOUGHTON 1 MILE
PROPOSED LOCATION FOR THE OFF-PROPERTY PUMPING TEST (SEE DRAWING 10006420-B3) FOR PUMPING TEST LAYOUT DETAILS)
RW-1
MW1
MW13
MW19
MW25,P25B
MW18
MW22,P22B,P22C
MW33,P33B
MW7,P7B
P8A,P8B
OB-3
OB-6
OB-5
MW30,P30B,P30C
P17B,P17C,P17D
OB-2
OB-1
OB-4
MW14,P14B
MW31
MW20
MW23
MW26,P26B,P26C
MW27,P27B
MW28,P28B,P28C
MW32,P32B
TB1
MW35,P35B
TB2
TB3
TB4
TB5
TB6
MW15
MW16
MW29,P29B,P29C
MW37,P37B
MW36,P36B
MW38,P38B
MW34,P34B

LEGEND

Symbol	Description
877.5	SPOT ELEVATION
875	GROUND CONTOUR (CONTOUR INTERVAL: 5 FT)
	DEPRESSION
	FENCE LINE
	TREES AND SHRUBS
	BUILDING
	SURFACE WATER
	APPROXIMATE PROPERTY LINE
T83	TEST BORING LOCATION AND NUMBER
P17B, P17C, P17D	MONITORING WELL NEST LOCATION AND WELL NUMBER(S) (MW = WATER TABLE WELL P = PIEZOMETER)
	PRIVATE WATER SUPPLY WELL LOCATION
OB-1	EXISTING ON PROPERTY PUMPING TEST OBSERVATION WELL LOCATION AND NUMBER
RW-1	EXISTING ON PROPERTY PUMPING TEST EXTRACTION WELL LOCATION AND NUMBER
3	EXISTING STAFF GAUGE LOCATION AND NUMBER
	PROPOSED OFF PROPERTY PUMPING TEST OBSERVATION WELL LOCATION (SEE DRAWING 10006420 B3 FOR PUMPING TEST LAYOUT DETAILS)
	PROPOSED OFF PROPERTY PUMPING TEST EXTRACTION WELL LOCATION (SEE DRAWING 10006420 B3 FOR PUMPING TEST LAYOUT DETAILS)
MW35, P35B	PROPOSED WELL NEST LOCATION AND WELL NUMBER(S) (MW = WATER TABLE, P = PIEZOMETER) [illegible] REPRESENT PROPOSED MONITORING LOCATIONS UNDER THE ALTERNATE MONITORING PLAN, SEE TEXT APPENDIX A SECTION 2.4.1)

NOTES

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY PERFORMED BY [illegible] DATED APRIL 18, 1988. ADDITIONAL TOPOGRAPHIC SURVEY WITHIN GRID LINES [illegible] PERFORMED BY [illegible] ASSOCIATES, INC. ON NOVEMBER 16 AND DECEMBER [illegible] (CONTOUR INTERVAL: 1 FT).
2. TOPOGRAPHY IS SHOWN IN U.S.G.S. DATUM.
3. GRID BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM.
4. SITE CONTAINMENT FENCE LINE LOCATED APPROXIMATELY BASED ON VISUAL OBSERVATION.
5. MONITORING WELLS [illegible] WERE INSTALLED [illegible] DURING JULY OF 1982. MONITORING WELLS [illegible] MW18 [illegible] WERE INSTALLED BY ETI DURING AUGUST OF 1988. MONITORING WELLS P13, P17E, MW22 AND [illegible] WERE INSTALLED BY ETI DURING SEPTEMBER OF 1988. MONITORING WELLS P17C, P22F, MW25, P25B, MW26, P26B, MW27, P27B, MW28, P28B, MW29, P29B, MW30, P30B AND MW31 WERE INSTALLED BY ETI DURING JULY AND AUGUST OF 1989. MONITORING WELLS P17D, P22C, P26C, P28C, P29C, MW31, P32B, MW33 AND P33B WERE INSTALLED BY ETI DURING APRIL, MAY AND JUNE OF 1990. PUMPING TEST WELLS [illegible] AND RW-1 WERE INSTALLED BY LAYNE NORTHWEST DURING OCTOBER, NOVEMBER AND DECEMBER OF 1990. MONITORING WELLS MW34 AND P34B WERE INSTALLED BY ETI DURING MARCH OF 1991.
6. MONITORING WELL AND PUMPING TEST WELL LOCATIONS AND ELEVATIONS ARE BASED ON SURVEYS CONDUCTED BY WASTE MANAGEMENT DURING NOVEMBER 1987, [illegible] AND ASSOCIATES DURING SEPTEMBER 1988, WARZYN INC. DURING OCTOBER AND DECEMBER 1988, SEPTEMBER 1989, JUNE AND DECEMBER 1990 AND JANUARY AND MARCH 1991.
7. BORINGS P30B, P39B, AND P40B ARE GROUNDWATER QUALITY TEST BORINGS THAT MAY NOT BE INSTRUMENTED AS WELLS.

0 400 800
SCALE IN FEET

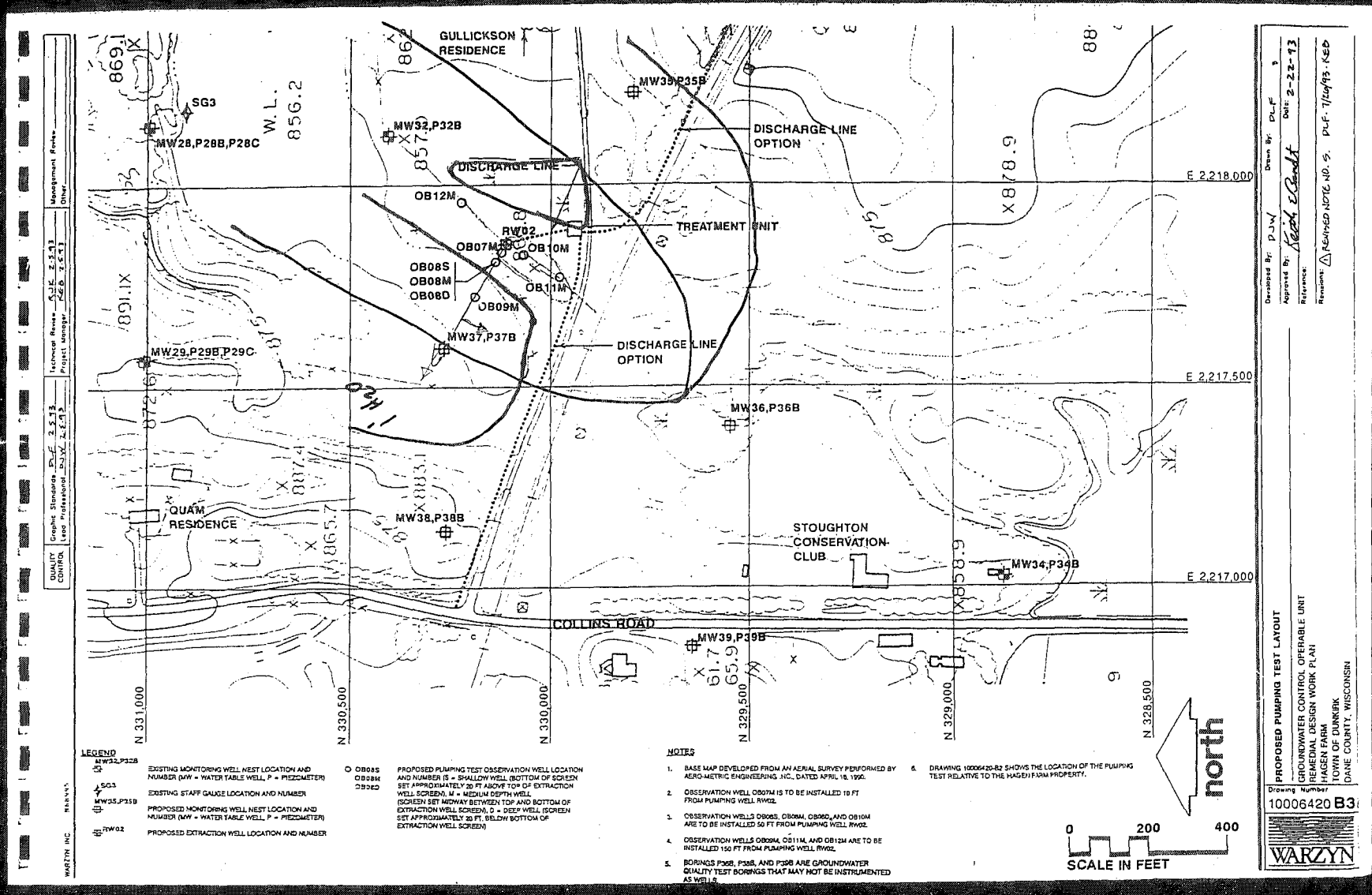
Checked By: DJW | Drawn By: DLF
Approved By: [signature] | Date: 2-22-93
Reference:
Revisions: 1 HIGHLIGHTED WELLS MW20, P22C, AND MW33, P33B DLF 6/29/93 JDP
2 HIGHLIGHTED WELLS P30B & P39B REVISED NOTE NO. 7. DLF 7/26/93 KEB

EXISTING FEATURES, AND PROPOSED MONITORING WELL, PUMPING TEST, AND GROUNDWATER QUALITY BORING LOCATION MAP

GROUNDWATER CONTROL OPERABLE UNIT
REMEDIAL DESIGN WORK PLAN
HAGEN FARM
TOWN OF DUNKIRK
DANE COUNTY, WISCONSIN

Drawing Number 10006420 B2

WARZYN



LEGEND

MW32,P32B — EXISTING MONITORING WELL NEST LOCATION AND NUMBER (MW = WATER TABLE WELL, P = PIEZOMETER)

SG3 — EXISTING STAFF GAUGE LOCATION AND NUMBER

MW35,P35B — PROPOSED MONITORING WELL NEST LOCATION AND NUMBER (MW = WATER TABLE WELL, P = PIEZOMETER)

RW02 — PROPOSED EXTRACTION WELL LOCATION AND NUMBER

OB08S, OB08M, OB08D — PROPOSED PUMPING TEST OBSERVATION WELL LOCATION AND NUMBER (S = SHALLOW WELL (BOTTOM OF SCREEN SET APPROXIMATELY 20 FT ABOVE TOP OF EXTRACTION WELL SCREEN), M = MEDIUM DEPTH WELL (SCREEN SET MIDWAY BETWEEN TOP AND BOTTOM OF EXTRACTION WELL SCREEN), D = DEEP WELL (SCREEN SET APPROXIMATELY 20 FT. BELOW BOTTOM OF EXTRACTION WELL SCREEN)

NOTES

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY PERFORMED BY AERO-METRIC ENGINEERING, INC., DATED APRIL 10, 1990.
2. OBSERVATION WELL OB07M IS TO BE INSTALLED 10 FT FROM PUMPING WELL RW02.
3. OBSERVATION WELLS OB08S, OB08M, OB08D, AND OB10M ARE TO BE INSTALLED 50 FT FROM PUMPING WELL RW02.
4. OBSERVATION WELLS OB09M, OB11M, AND OB12M ARE TO BE INSTALLED 150 FT FROM PUMPING WELL RW02.
5. BORINGS P36B, P38B, AND P39B ARE GROUNDWATER QUALITY TEST BORINGS THAT MAY NOT BE INSTRUMENTED AS WELLS.
6. DRAWING 10006420-B2 SHOWS THE LOCATION OF THE PUMPING TEST RELATIVE TO THE HAGEN FARM PROPERTY.

QUALITY CONTROL
Graphic Standards DJW 2.5.93 — Management Review — Other
Lead Professional DJW 2.5.93 — Technical Review AJK 2.5.93 — Project Manager KED 2.5.93

Designed By: DJW Drawn By: PLF Date: 2-22-93
Approved By: Kevin E Boudt
Reference:
Revisions: 1 REVISED NOTE NO. 5. PLF 7/14/93 KED

PROPOSED PUMPING TEST LAYOUT
GROUNDWATER CONTROL OPERABLE UNIT
REMEDIAL DESIGN WORK PLAN
HAGEN FARM
TOWN OF DUNKIRK
DANE COUNTY, WISCONSIN

Drawing Number 10006420 B3

WARZYN INC. WARZYN

WARZYN

97-00

ATTACHMENT A

TO THE

GROUNDWATER MONITORING PLAN

WASTE MANAGEMENT OF WISCONSIN
WELL CONSTRUCTION AND DEVELOPMENT

TABLE OF CONTENTS

PART I – INTRODUCTION

Drilling and well construction services are generally subcontracted by the Consultant of Record, on behalf of WMI, in accordance with prevailing Master Agreements. Therefore, the only contractual issue this specification addresses is the method of subcontractor selection and reimbursement for drilling and well installation services.

Since the consultant of record is ultimately responsible for adherence to this well specification and the quality of the work products and deliverables, the selection of a qualified drilling firm is the consultant's responsibility. WMI does reserve the right to request documentation of the selected or proposed drilling firm's qualifications and experience and to reject the subcontracting of drilling firms which WMI deems to be unqualified. Such rejections will constitute the basis for renegotiation of that portion of the contract pertaining to drilling and well installation.

WMI expects the consultant to procure cost effective drilling and well installation services through the competitive bidding process. WMI reserves the right of prior approval to review and make recommendations to the consultant prior to the consultant's awarding the drilling subcontract.

Drilling and well construction services performed at WMI facilities should be performed on principally a footage and materials basis in accordance with a previously submitted and accepted schedule of fees. An example of a fee schedule that would be provided in a bid package is shown on Table A–1. All drilling activities should be reimbursed on a per foot basis. The basic drilling footage rate must include, but is not limited to, any sample and testing protocols which are specified as part of the scope of work, estimated drilling depths, estimated number of borings, decontamination of drilling tools between individual borings, and the cost of any basic safety monitoring equipment or personal protection clothing that is required by the drilling firm or its insurance carrier.

Separate footage rates should be provided for different drilling methods or equipment requirements. Footage surcharge fees should be provided for work performed in adverse

TABLE A–1
EXAMPLE OF STANDARD SCHEDULE OF FEES
DRILLING AND WELL CONSTRUCTION

ACTIVITY/ITEM	UNIT RATE	ESTIMATED UNITS	EXTENDED COST
Mobilization/Demobilization	____ per event	2 events	
Drilling and Sampling			
• 8" hollow stem auger with continuous sampling	____ per ft.	300 ft.	
• 8" hollow stem auger with SPT sampling at 5 ft. intervals	____ per ft.	150 ft.	
• NX rock coring with packer testing at 10 ft. intervals	____ per ft.	500 ft.	
• Footage surcharge for adverse weather conditions[1]	____ per ft.	425 ft.	
• Footage surcharge for Level C personnel protection	____ per ft.	450 ft.	
• Footage surcharge for Level B personnel protection	____ per ft.	500 ft.	
Well Construction and Completion	____ per well	10 wells	
On-Site Set-Ups and Moves	____ per set-up	10 set-ups	
Well Construction Materials			
• 2" ø Schedule 40 PVC casing with flush threads	____ per ft.	450 ft.	
• 2" ø Schedule 40 PVC well screen with flush threads	____ per ft.	500 ft.	

TABLE A-1 (continued)

ACTIVITY/ITEM	UNIT RATE	ESTIMATED UNITS	EXTENDED COST
Well Construction Materials continued			
• No. 2 sieve size gravel pack	____ per cu. yd./bag	15 cu. yd.	
• No. 18 sieve size filter pack	____ per cu. yd./bag	2 cu. yd.	
• Bentonite pellets	____ per 50 lb./bucket	15 50 lb. buckets	
• Powdered bentonite	____ per 50 lb. bags	20 50-1b. bags	
• Cement	____ per 94 lb. bag	100 94-1b. bags	
• Aluminized protective surface casings	____ per casing	10 casings	
• 2" ø PVC well caps	____ per cap	10 caps	
• 2" ø PVC end plugs	____ per plug	10 plugs	
• PVC well centralizers	____ per centralizer	80 centralizers	
Drill Crew Per Diem	____- per man-day	25 man-days	
Authorized Standby	____- per hour	20 hours	

1 For purposes of this contract, adverse weather conditions will be defined as wind chill index below 10° F or temperature humidity index (THI) above 92. Work is not expected to continue during periods of hard rain, sleeting conditions, when the wind chill index is below –20° F, or when the THI is above 108° F.

weather conditions, in Level A, B, or C personnel protective attire, or for deep borings. Mobilization/demobilization, on-site moves and set-ups, and well construction (including development) should be reimbursed on a per event basis. All well construction materials and expendable items (i.e., drill bits, auger baskets, core boxes, etc.) should be reimbursed on a unit cost basis. Authorized standby is the only item which will be reimbursed on an hourly basis.

To facilitate subcontractor conformance with this reimbursement method, WMI recommends that the consultant provide the bidding firms with a formatted fee schedule, such as that shown on Table A-1, complete with the estimated units. The estimated drilling depths and number of borings should also be provided.

PART II – GENERAL CONDITIONS

SECTION 2.1 – DEFINITIONS

2.1–01 Agreement

The contract between the Owner and Contractor including supplements and change orders issued by the Owner's Representative.

2.1–02 Annular Space

The space between two concentric tubes or casings, or between the casing and the well hole.

2.1–03 Aquifer

A geologic formation, group of formations, or part of a formation that is saturated, and contributes a significant quantity of water to wells or springs.

2.1–04 Artesian

A condition in an aquifer where the groundwater is confined under pressure.

2.1–05 ASTM

The American Society for Testing and Materials provides guidelines and standards for material testing. The address is 1916 Race Street, Philadelphia, PA 19103.

2.1–06 Bailer

A tabular hollow receptacle with a check valve used to facilitate withdrawal of fluid from a well or borehole.

2.1–07 Bentonite

A highly plastic absorptive, colloidal natural clay composed largely of sodium montmorillonite and which is sold commercially in dry powder or pelletized form.

2.1–08 Bid

The offer or proposal of the bidder submitted on the prescribed form setting forth the prices for the work to be performed.

2.1–09 Bidder

Any person, firm, or corporation invited to submit a bid for the work.

2.1–10 Blow Out

The inflow of groundwater and soil into the well hole or casing caused by a differential pressure head greater outside the well hole or casing than inside, generally due to a lower water level inside the well hole than that of the surrounding potentiometric level.

2.1–11 Casing

Tubular steel, finished in sections with either threaded connections or bevelled edges to be field welded, which is installed to counteract caving of the drilled hole.

2.1–12 Casing, Flush Joint

Casing with squared threaded ends such that a fixed inside and outside diameter is maintained across joints.

2.1–13 Casing, Protective

Anodized aluminum pipe with aluminum locking lid with provisions for a heavy duty padlock installed at 3 feet above ground surface to protect the PVC well from damage.

2.1–14 Casing, Surface

A single section of clean black steel pipe used to stabilize the well hole near the surface during the initial drilling of the hole.

2.1–15 Cement

Portland Cement Type 1 meeting ASTM C 150 furnished in 94 pound bags.

2.1–16 Cement Float Shoe

A plug or packer constructed of inert materials within the lowermost section of permanent casing fitted with a passageway through which grout is injected under pressure to fill the annular space. After the grout has hardened, the cement float shoe is drilled out.

2.1–17 Centering Disk

A flat, perforated disk constructed of PVC which slides over the riser and/or well screen and fits inside the temporary casing or hollow-stem auger to center the riser within the casing.

2.1–18 Centralizer

See Centering Disk.

2.1–19 Change Order

A written order to the Contractor signed by the Owner's Representative authorizing an addition, deletion, or revision in the work, or an adjustment in the Contract price or the contract time issued after execution of the agreement.

2.1–20 Conductivity

See Specific Conductance.

2.1–21 Cone of Depression

The zone influenced by withdrawal of water from an aquifer by some artificial or natural means such as a pumped well, leak, or spring.

2.1–22 Confined Aquifer

Groundwater under pressure significantly greater than atmospheric pressure; the upper limit of the aquifer being the bottom of a zone of distinctly lower hydraulic conductivity than that of the material in which the confined water occurs.

2.1–23 Contractor

The person, firm, or corporation with whom the Owner has executed the agreement.

2.1–24 Cuttings

The fragments, particles, or slurry of soil or rock created during the drilling of the well hole.

2.1–25 D.C.D.M.A.

The Diamond Core Drill Manufacturer's Association.

2.1–26 Drawdown

The difference in elevation between the static water level and the surface of the cone of depression at the time of development.

2.1–27 Drawings

Refer to the attached for drawing of single– and multi–cased wells.

2.1–28 Drilling Fluid

A water based fluid used in the drilling operation to wash cuttings from the hole, to clean and cool the bit, to reduce friction between the drill stem and sides of the hole, and to seal the sides of the hole to prevent loss of drilling fluids. NOTE: COMMERCIAL DRILLING FLUIDS WITH ADDITIVES ARE NOT TO BE USED.

2.1–29 Drive Shoe

A forged steel collar with a cutting edge fastened onto the bottom of the casing to shear off irregularities in the hole as the casing advances, and to protect the lower edge of the casing as it is driven.

2.1–30 d–15

The theoretical diameter of the soil particle in millimeters at which 15 percent of the particles are finer and 85 percent are coarser.

2.1–31 d–85

The theoretical diameter of the soil particle in millimeters at which 85 percent of the particles are finer and 15 percent are coarser.

2.1–32 Engineer

An individual with a degree in civil engineering and having experience in the installation of monitoring wells, who is employed by the consultant.

2.1–33 Filter

A clean sand of selected grain size and gradation which is installed in the annular space between the well pipe and the wall of the casing or well hole above the gravel pack and below the bentonite seal.

2.1–34 Geologist

An individual with formal training in the science of geology.

2.1–35 Gravel Pack

A gravel or coarse sand installed between the well screen and the well hole extending 5 feet above the top of the well screen.

2.1–36 Groundwater

Naturally occurring water encountered below the ground surface.

2.1–37 Grout

A mixture of cement, bentonite, lime, and water which is used to form a seal between the borehole and well casing.

2.1–38 Hazardous Waste

A hazardous waste as defined by the Resource Conservation Recovery Act (RCRA) in 40 CFR 261.3.

2.1–39 Homogeneous

The property of a material to be essentially uniform in its characteristics of composition, texture, appearance, etc.

2.1–40 Hydraulic Gradient

The change in static head per unit of distance in a given direction. If not specified, the direction of flow generally is understood to be that of the maximum rate of decrease in head.

2.1–41 Jetting

Water is forced down through the drill rods or well by means of the pressure pump and out through holes in the bit or well screen. This water, being under pressure, creates a quick condition and allows the well or drill rods to sink into the soil or cuttings.

2.1–42 Leachate

Contaminated water resulting from the passage of rain, surface water, or groundwater through waste.

2.1–43 Lower Zone

A readily defined soil strata consisting of a predominate soil type different from the zone(s) above it.

2.1–44 Measuring Tape

An electronic water level indicator which utilizes the water as a conductor to indicate submergence of a point containing an energized probe and a neutral wire separated by a short distance.

2.1–45 Mud Pan

A metal tub into which the drilling fluid and cuttings are discharged and which serves as a reservoir and settling tank during recirculation of the drilling fluids.

2.1–46 Oil Trap

A filter and separator used to remove oil from the compressed air flowing out of the storage tank.

2.1–47 Owner

The legal owner of the facility for which the work is being performed.

2.1–48 Owner's Representative

The authorized representative of the Owner who is assigned to the project and who has the authority to bind the Owner to an agreement.

2.1–49 Packer

A device temporarily placed in a well which plugs or seals a portion of the well at a specific level.

2.1–50 Perched Groundwater

Groundwater in a saturated zone of relatively limited horizontal extent which is separated from the main body of groundwater by an unsaturated zone or thick zone of low permeability.

2.1–51 Permeability

A measure of the relative ease with which a porous medium can transmit a liquid under a potential gradient. It is a property of the medium that is dependent upon the shape and size of the pores. The rate at which water flows through a soil deposit in response to a differential in hydraulic pressure.

2.1–52 pH

The intensity of acidic or alkaline condition of a solution; the symbol for the logarithm of the reciprocal of hydrogen ion concentration in gram–atoms per liter.

2.1–53 Potentiometric Level

The level in or above a confined or unconfined aquifer at which the pressure is atmospheric. This level is determined at a location by the static water level in a monitoring well screened in the aquifer.

2.1–54 Reaming

The process of enlarging the well hole to remove geologic material from the sides of the well hole.

2.1–55 Revert(R)

An organic polymer drilling fluid additive of high viscosity manufactured by the Johnson Well Screen Company. NOT TO BE USED PER WMI SPECIFICATIONS.

2.1–56 Riser

The pipe extending from the well screen to above the ground surface.

2.1–57 Seal Tamper

A heavy cylindrical metal section of tubing which is secured to a cable that slips over the riser and fits inside the casing or well hole which is used to tamp the bentonite pellets, gravel pack, or filter.

2.1–58 Specifications

The instructions to bidders, the general conditions, the special conditions, and the technical provisions.

2.1–59 Specific Conductance

The potential for electrical conductivity of a water sample at 25°C as expressed in micro–ohms per centimeter.

2.1–60 Standby

Authorized periods of shut–down whereby drilling and well installation stop by orders of the Owners Representative.

2.1–61 Static Water Level

The vertical elevation of the top of a column of water in a monitoring well which is no longer influenced by effects of installation, pumping, or other temporary conditions.

2.1–62 Stick-up

The vertical length of the portion of the protective casing which protrudes above the ground surface.

2.1–63 Subcontractor

An individual, firm, or corporation employed by the Contractor or any other subcontractor for the performance of a part of the work at the site, other than employees of the Contractor.

2.1–64 Transmissivity

The rate at which water of prevailing kinematic viscosity is transmitted through a unit width of an aquifer under a unit hydraulic gradient.

2.1–65 Tremie Pipe

A pressurized pipe or tube used to transport the flow of grout from the surface into the annular space beginning at the bottom of the annular space and proceeding upwards. (NOTE: HORIZONTAL OR SIDE DISCHARGE IS REQUIRED.)

2.1–66 Uniformly Graded

A particle size distribution of a soil which consists of the majority of particles being of the same appropriate diameter.

2.1–67 Upper Zone

A soil strata consisting of a dominant soil type different from the zone immediately below it.

2.1–68 Utilities

Service lines or equipment located above, upon, or below the ground surface used for conveyance of electricity, natural gas, petroleum, communications, storm water, waste water, potable water, etc.

2.1–69 Washout Nozzle

A device utilized at the end of a string of casing equipped with a check valve through which clear water or grout can be injected to wash out drilling fluids and cuttings from the annular space.

2.1–70 Water Cement Ratio

The proportion of the weight of mixing water in pounds to weight of cement in pounds.

2.1–71 Water Table

The surface in an unconfined aquifer at which the pressure is atmospheric. This level is determined at a location by the static water level in a monitoring well screened in the aquifer.

2.1–72 Well Hole

The open subsurface hole created by conventional drilling methods.

2.1–73 Well Protector

See Casing, Protective.

2.1–74 Well Screen

Commercially manufactured pipe or cylindrical tubing with slits of a uniform width, orientation, and spacing.

2.1–75 Zone of Saturation

The zone below the water table or below the top of a confined aquifer in which all interstices are filled with groundwater.

PART III – TECHNICAL PROVISIONS

SECTION 3.1 – GENERAL

3.1–01 Well Locations and Dimensions

A. General. General well locations are provided on the Permit or in the Scope of Work. Prior to drilling, the Contractor and the Consultant of Record should establish the exact location of each well by conventional field inspection methods, giving consideration to the requirements established by the Local, State, and Federal Agency permit requirements so as to avoid utility interference and to provide useful data and an accessible well. Subsequent to well construction, the exact location and elevation at each well should be established by conventional survey methods.

B. Surveying. The Contractor should determine:

1. Horizontal coordinates of wells to an accuracy of ±1.0 foot, relative to the facility grid.

2. Ground elevation at well to an accuracy of ±0.01 foot MSL.

3. Elevation of top of well casing and top of protective casing to an accuracy of ±0.01 foot.

C. A benchmark and horizontal control on the facility property will be provided by the Owner. All surveying will commence at the provided control and will traverse to the well and back to the control using standard closure procedures. A copy of the field notes should be furnished to the Owner.

D. Water. The source of water to be used, if any, will be identified by the Owner's Representative. The Contractor should locate the source of water by

survey. If the source is a well, include the log for the well with the monitoring well logs. If the well log is unavailable, do not use that source. The source of water must be analyzed by the Owner before it may be used.

E. Depth of Well and Screen Placement

1. Determine the elevation of the top and bottom of the well screen referenced to MSL ±0.1 foot.

2. Determine the bottom of the drilled hole referenced to MSL ±0.1 foot.

3. The dimensions of the casing, riser, and well screen should be reported in inches.

4. All elevation data should be shown on the well log.

3.1–02 Permits and Utility Clearances

A. Licensure. The Contractor should be legally qualified, and, if necessary, licensed to install wells in the state or county in which wells are being installed.

B. Utilities. The Contractor should ascertain that well construction does not interfere with overhead and underground utilities. Do not proceed until utilities are cleared. If a field tile or other feature is encountered, stop and notify the Owner's Representative for instruction as to whether to abandon the hole or modify the well casing.

C. Permits. Where permits are required by the State to install wells at a particular site or location, the Owner's Representative or Contractor should obtain all permits required. The Contractor should also be responsible for compliance with all conditions of the permit during installation of the wells.

D. Conflicts. All work should be done in accordance with applicable Federal and State regulations; however, if a conflict between these specifications and other regulations exists, the Contractor should request clarification from the Owner's Representative.

3.1–03 Documentation

A. General. This section covers the record keeping procedures and documentation required for the acceptance of a well by the Owner's Representative. WMI has developed standard forms for borehole logging and documenting well construction details. Additional forms summarizing daily drilling and well construction activity are also available from WMI District offices. These forms should be utilized by the Contractor. Submission of nonstandard documentation or Contractor's forms in lieu of the WMI standard forms will result in rejection of the forms by the Owner's Representative. Copies of these forms are provided in Appendix D, along with detailed instructions and completed examples.

B. Surveying. The surveyed location and elevation data on the well as specified in Section 3.1–01 should be presented on the log of the well hole. Coordinates and MSL elevation references should be utilized unless other instructions are given by the Owner's Representative.

C. Well Hole Logging. A geotechnical engineer or geologist should be present during the well drilling, construction, and development operations to represent the Contractor and to document the field work. The engineer/geologist should direct the sampling, log the well hole, document on-site testing activities and results, and maintain daily records of the Contractor's activities. A typed boring log should be developed from the field log and the laboratory test results (see Appendix D for standard boring logs). A daily drilling summary should also be prepared using WMI standard forms and submitted to the Owner's Representative.

D. Well Construction Record. The Contractor should develop an as-built drawing of the well showing the elevations of the ground, the static water level, top of riser, top and bottom of gravel pack, top of seal, length of permanent steel casings, strata, etc. The diameter and thickness of the casing and riser, the well screen slot size, and any other pertinent information should be presented on the WMI standard forms presented in Appendix D. The format of the sketch should be ink on mylar, or comparable.

E. Well Recovery Graph. A well recovery graph should be presented on the well construction record. If recovery is instantaneous, it should be noted on the record. A tabulation of recovery test readings should be furnished. The interval of readings will vary depending on the aquifer characteristics, and the Engineer should establish the pattern of readings that is appropriate (refer to Appendix D).

F. Number and Disposition of Copies. Four copies of the typed well boring log and the well construction record should be furnished to the Owner's Representative (refer to Appendix D).

G. Examples. Example boring logs, well construction records, and well recovery graphs are attached (Appendix D).

3.1–04 Measurement for Payment

A. General. This section describes the methods to be used to determine the quantities and units of work completed and for which payment will be made by the Owner to the Contractor for all work and materials required to construct the wells.

B. Mobilization. Mobilization includes all work preparatory to arriving at the site including the purchase and delivery of materials; clearing utilities; surveying the well locations; transporting the drill rig, tools, engineer, and

operators to the site; and the removal of all unused materials, all equipment, and personnel from the site. Removal of trees and construction of temporary roads is not included in mobilization. This cost is based on time and materials in accordance with the fee schedule. If the work is terminated by the Owner's Representative for failure of the Contractor to adhere to the specifications or because the method of well drilling proposed by the Contractor proves infeasible, then the Contractor should be paid only for a prorated portion of the amount bid for mobilization. The prorated amount to be paid for mobilization should be based on the percentage of wells completed and accepted by the Owner's Representative, except that the minimum payment for mobilization in the event the contract is terminated before the Contractor begins drilling in which event no payment should be made. No other materials including wells which are abandoned, incomplete, or which are not accepted by the Owner's Representative.

C. Monitoring Wells. Monitoring wells which are drilled, fitted with a well screen and well pipe, and developed in accordance with these specifications and accepted by the Owner's Representative should be paid for at the unit price bid for monitoring wells, measured from ground surface to the bottom of the well screen, which payment should be the total compensation for all work and materials. No other payment will be made and all other work including documentation, well development, and field and laboratory soils testing should be considered incidental to the unit price established for monitoring wells. Any special laboratory soil testing work should be a separate unit price.

SECTION 3.2 – DECONTAMINATION OF EQUIPMENT AND MATERIALS

3.2–01 General

This section covers the decontamination of equipment, tools, and materials utilized in the well construction.

3.2–02 Condition of Drill Rig and Equipment

The condition of the equipment should be such that contamination is not created. Leaking seals, hoses, pumps, or tanks containing oils and fluids other than water should not be permitted.

3.2–03 Procedures to be Used for Cleaning Equipment

A. All cleaning is to be performed on site.

B. Remove all drill rods, augers, samplers, and other equipment except that in the tool boxes of the rig which will not be utilized in the operations. Color code or lock the tool boxes as a precaution to prevent contaminated tools from being used.

C. Steam clean the drill rig utilizing water only from the source designated by the Owner's Representative or another approved source. Sample the water used in the process and retain the sample for 90 days after well completion. Record the name, model, and serial number of the steam cleaning unit.

D. Lay drill rods, augers, casing, samplers, pipe wrenches, etc., on horses or other supports and clean until all visible signs of grease, oil, mud, etc., are removed. Use brushes as required.

E. Do not use greasy gloves when handling tools after cleaning. Surgeons' gloves or new clean cotton work gloves should be used.

F. Do not use new painted bits and tools which will leave paint chips in the hole.

G. Pumps – clean water tanks, pumps, mud pans, hoses, including hoses and tanks used to transfer water from the source to the drill rig tank, i.e., pickup truck water tanks.

H. Fittings on the drilling equipment may be greased and fluids may be added to the equipment with care before cleaning. Precautions should be taken to prevent contamination of the well with oil and grease. Lubricants should not be used on the drilling and sampling tools or fittings thereto.

3.2–04 Decontamination of Materials

A. Use only new materials that have been certified by the manufacturer (refer to 3.5–01). Only bagged cement, powdered bentonite in bags, or bentonite pellets in well protectors should be used.

B. Use PVC pipe for riser and well screen which has cured and is free of plasticizers. Oil should not be used during the factory threading operations.

C. Factory cleaned PVC pipe should be supplied. Workers should use clean cotton gloves when handling riser and well screen.

D. Steam clean the protective well casing and any casing pipe which was not cleaned and properly sealed by the manufacturer.

E. Water used in drilling and grouting operations is to be obtained only from the source designated by the Owner's Representative.

3.2–05 Decontamination of Well DeveloPment Tools

A. All pumps used in well development should be steam cleaned with the water specified in Section 3.2–04E. Pumps which leak or otherwise may cause contamination will not be used. Electrical tape should not be used to band pumps. Bands should be stainless steel or plastic ties.

B. Only compressors equipped with operable oil traps and a filter should be utilized. The oil trap and filter should be of a design approved by the Owner's Representative.

C. Nitrogen gas, if utilized, should be regulated before it enters the well. The source of the nitrogen should be identified in the report.

SECTION 3.3 – DRILLING PROCEDURES AND STEEL CASING INSTALLATION

3.3–01 General

This section covers creating a stable, open, vertical well hole for installation of the well screen and riser. The method listed on the Bid Form should be utilized except if the method indicated is unsuccessful, in which case the Contractor should notify the Owner's Representative and the Contractor should stop work. If the method proposed by the Contractor is unsuccessful, the Owner's Representative may terminate the contract, in which case the Contractor should abandon the hole. The Contractor will be paid only for the prorated mobilization. Abandoned holes should be grouted by the Contractor in accordance with Section 3.3–10 and this should be incidental to mobilization. Following contract termination, the Owner's Representative may negotiate a new contract with the Contractor or other Bidders to construct the wells.

3.3–02 Prohibited Methods

Addition of drilling fluids containing chemical additives or organic matter during the drilling of the well hole such as Bariod® (East mud) or Revert® is prohibited. Mixing of water or cuttings from upper zones with lower zones is prohibited, and any drilling method which has the potential to cause such mixing should not be utilized.

3.3–03 Preferred Drilling Procedures

Whenever feasible, the Contractor is encouraged to utilize drilling procedures which do not require the introduction of water or liquid drilling fluids into the well

hole. In general, the following drilling methods are listed in decreasing order: 1) drilling with hollow stem augers is the most preferable method; 2) air rotary drilling with an oil filter/trap; 3) cable tool methods and other percussion tool drilling methods may be attempted in hard, consolidated formations; 4) reverse circulation drilling fluid is preferable to wet rotary drilling; and 5) wet rotary drilling with clear water only and insertion of temporary flush joint casing are subject to approval of the Owner's Representative, with particular consideration being given to the procedures used to prevent mixing of upper zones with lower zones.

3.3–04 Double Cased Wells

As shown on the drawings or where conditions warrant, the use of permanent steel casing installed to prevent mixing of upper zones with lower zones is encouraged. Conceivably, several permanent casings may be required. Installation of permanent steel casing should be completed prior to drilling into a lower zone. A cement float shoe should be utilized in grouting the annular space between the well bore and the permanent steel casing except when the casing is driven and a tight seal is created between the well bore and the steel casing. When a steel casing is installed in a predrilled hole and then driven, the driven length of permanent casing should be at least 3 feet. An alternate procedure to the use of a cement shoe, and always when permanent steel casing is inserted in a predrilled hole and driven below the bottom of the predrilled hole, should be to fill the predrilled hole with grout via a tremie pipe, insert the casing and drive it while the grout is still plastic. The grout inside the casing may be washed or drilled out, except that during the period between 1.5 hours and 48 hours after mixing of the grout, the casing should not be disturbed.

3.3–05 Hollow Stem Auger Drilling

Where a monitoring well screen is to be constructed in a saturated, permeable zone of soil under low or no artesian pressure overlain by a continuous zone of low

permeability soils free of saturated interbedded zones of permeable soils, hollow stem augers may be utilized to drill and stabilize the well hole. The inside diameter of the hollow stem auger should be at least 1.33 times the outside diameter of the well screen and riser. Only hollow stem augers with water-tight joints should be utilized.

When "blow out" occurs, the hollow stem auger should be filled with water from the approved source, and a three inch diameter split spoon sampler or other decontaminated tool driven into the "blow out" to carefully clean the hole. A roller bit or jetting should not be used to clean the hole.

3.3–06 Rotary Drilling with Clear Water and Temporary Flush Joint Steel Casing

A. General. This technique utilizes temporary steel flush joint casing to stabilize the well hole, rotary drilling to cut and pulverize the formation, and clear water as a medium to cool the bit and wash the cuttings from the well hole. This technique requires a large source of clear water; a drill rod with a large inside diameter, a high capacity, high pressure pump; and a drill with high torque and weight. This drilling technique is encouraged where the depth of well hole exceeds the depth to which hollow stem augers are adaptable; where sandy, bouldery, or gravelly soils or weathered bedrock must be penetrated and temporarily cased to create an open well hole.

B. Tools to be Utilized

1. Only flush joint steel casing with an inside diameter at least 1.33 times the outside diameter of the screen and riser should be utilized.

2. The roller bit or drag bit should create a well hole no more than 3/8 inch smaller than the inside diameter of the casing. Preferably, these bits should be of the side discharge design.

3. The drill rod should have a minimum inside diameter of 1.375 inches.

4. The water swivel should have a minimum inside diameter of 1.25 inches. The pump hose should have a minimum inside diameter of 1.50 inches.

5. A settling tank and screens may be used if the pump creates an up hole velocity of 100 to 150 feet per minute. Note that the velocity will depend on the inside diameter of the casing and the outside diameter of the drill rod, as well as the pump capacity.

C. Procedure. The well hole should be drilled and the casing driven in increments of 5 feet maximum. The addition of bentonite should not be permitted. Blow out should be counteracted by maintaining the casing full of water at all times. Bentonite powder may be added at the surface to the outside of the casing to lubricate the outside of the casing and facilitate removal. The rotation speed and rate of bit feed should be such that the formation being drilled is ground to medium to fine sand sized particles. The size of particles removed is related to the up hole velocity.

3.3–07 Air Rotary Methods

A. General. This technique utilizes temporary and/or permanent steel casing, rotary drilling, and compressed air as a medium to remove cuttings from the hole. The technique is only useful in hard formations where the rotary bit is not subject to plugging. The system requires a large air compressor, a large inside diameter drill pipe, a conventional water swivel, and large diameter hoses. The use of this method is encouraged when drilling at least 20 feet of medium to hard bedrock and coring is not required. This technique is especially useful where loss of water would be a problem if the hole was drilled wet rotary.

B. Tools to be Utilized

1. Steel casing should be set to create an open stable well hole down to the top of bedrock or the hard strata to be drilled by the air rotary method.

2. The compressor should deliver a minimum of 400 cfm, and sufficient pressure to create up hole velocities of at least 3 feet per second. The compressor should be equipped with filters to trap oil and other foreign materials from entering the well hole.

3. The drill rod should have a minimum inside diameter of 1.375 inches.

4. The water swivel and hose should have a minimum inside diameter of 1.25 inches.

C. Procedure. The rotation speed and drill advance rate should be low enough that cuttings are blown out of the well hole and do not clog the casing.

3.3–08 Cable Tool and Percussion Principles of Operation

A cable tool rig uses a heavy, solid steel chisel–type drill bit suspended on a steel cable which, when raised and dropped, chisels or pounds a hole through the soil and rock. When drilling through the unsaturated zone, some water may be added to the hole (refer to Section 3.1–01D for source of water). The cuttings are suspended in the water and then bailed out periodically.

When soft caving formations are encountered, it is necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is covered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole. The shoe, in fact, cuts a slightly larger hole than the drill bit. This

tight-fitting drive shoe should not, however, be relied upon to form a seal from overlying water-bearing zones.

3.3–09 Reverse Circulation

The common reverse circulation rig is a water or mud rotary rig with a large diameter drill pipe and which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from a direct mud rotary). This type of rig is used for the construction of large capacity production water wells and is not suited for small, water quality sampling. These techniques may be utilized subject to approval of the Owner's Representative.

3.3–10 Grouting Abandoned Well Holes

A. General. The purpose of properly abandoning a well hole is to prevent the hole from acting as a channel for contamination or vertical movement of water. The abandonment must be done in a manner that will not impair original water quality of the aquifer. All well abandoning procedures should be in accordance with state and local regulations.

B. Procedures. All cased wells in unconsolidated and consolidated formations should be completely over drilled 1.5 times larger than the original boring. The well hole should be grouted completely using a pressured tremie pipe (side discharge) method and a grout mixture as specified in Section 3.5–05.

SECTION 3.4 – SAMPLING OF FORMATIONS, WATER, AND MATERIALS

3.4–01 General

This section covers sampling the soil, bedrock, and groundwater. Geologic samples are required to determine the strata thickness and type and to provide the information necessary to develop a log of the well hole. Material samples are required to evaluate specification compliance.

3.4–02 Sampling Interval and Type

A. Continuous soil sampling is preferred, particularly in cohesive and semicohesive soils. At a minimum, soil should be sampled at regular intervals not exceeding 5 feet except that a minimum of two samples should be taken in any strata in which a monitoring well screen is to be set. Sampling should be performed in accordance with ASTM D 1586 or 1587. Place ASTM D 1586 samples in 8 ounce Paragon jars and seal. Exposed portions of samples taken in accordance with ASTM D 1587 should be sealed with nonshrinking wax.

B. Bedrock. Continuously core the zone of bedrock in which well screen is to be set, NX size or larger. At least 80 percent of the core run should be recovered except when the RQD is less than 25 percent, in which case 60 percent core recovery is acceptable. Core should be placed in commercial plastic, cardboard, or shop–made wooden core boxes and properly identified with core loss blocks provided.

C. Roller bit and percussion drilling cuttings should be logged at 3 foot intervals and sampled at 10 foot intervals, place samples in jars, and label if coring is specifically omitted by the Owner's Representative.

D. When drilling through old refuse or under other unusual conditions, sampling requirements will be at the Owner's Representative's discretion.

E. Water quality samples should be placed in bottles provided by the Owner.

F. A sample of the gravel pack should be placed in two (2) 8 ounce Paragon jars, labeled, and retained by the Contractor for 6 months.

G. A sample of the filter should be placed in two (2) 8 ounce Paragon jars, labeled, and retained by the Contractor for 6 months.

H. A sample of the plastic grout from each grouting operation on each well should be placed in an 8 ounce Paragon jar, labeled, and retained by the Contractor.

3.4–03 Testing and Storing of Samples

A. Cohesive samples should be tested for moisture content and Atterburg Limits.

B. If applicable, granular soil samples from the strata in which the well screen is set should be tested for particle size distribution, ASTM D 422.

C. The core, after placement in the core box and marking, should be photographed and color prints furnished with the report.

D. All soil or rock samples should be stored at the site until final site closure. The consultants may remove these samples to an off–site location for detailed inspection and analysis, but all samples must be returned to the WMI Site Manager. Inasmuch as these samples constitute the primary means of documenting the site subsurface conditions, they should be treated in the same manner as a permit document. The Site Manager will, therefore, be responsible for the storage and maintenance of these samples.

E. Other testing such as consolidation, permeability, and soil water characteristics should be performed at the Owner's Representative's request only.

F. Water quality samples should be stored for 180 days by the Contractor.

SECTION 3.5 – WELL CONSTRUCTION MATERIALS

3.5–01 General

This section stipulates the well construction materials including well screen, riser pipe, well protector, gravel pack, grout mix, and water. All materials used in construction should be free of chemicals, paint, coatings, etc., that could leach. All materials should be decontaminated in accordance with Section 3.2–04.

3.5–02 Well Screen

Continuously slotted PVC plastic well screen should be utilized, unless directed otherwise by the Owner's Representative. The diameter of the well screen should be as shown on the drawing. Well screen should be furnished in 5 foot long sections or longer. The bottom plug should be threaded and should withstand all installation and well development pressures without becoming dislodged or damaged. Unless instructed otherwise, typical screen slots size is 0.010 inch on all well screens.

3.5–03 Riser Pipe

The riser pipe should consist of PVC pipe meeting ASTM D 1785 with flush joint threads. Schedule 40 or 80 pipe, as designated on the drawing, should be utilized. The interval between joints should be 5 to 20 feet. "Triloc" Monitoring Well Pipe® with Teflon® taped joints and without "0" rings should be permitted in lieu of Schedule 40 PVC pipe.

A. Threads are to be in accordance with DCDMA standards or, by independent tests, the manufacturer should demonstrate equivalency of the threaded joint to crushing.

B. All joints should be Teflon taped.

C. Glued joints of any type should not be permitted.

D. Rivet joints should not be permitted.

E. The slot (screen) size should be determined relative to the formation and gravel pack in which the screen is to be set. The Contractor should make the screen selection based on field sieves.

F. The length of the screen should be as shown on the drawings. A minimum length of 5 feet should be provided.

3.5–04 Permanent Steel Casing For Permanently Double Cased Wells

A. The diameter of the casings in multi-cased wells should be selected so that a 2 inch annular space is maintained between the casing and the borehole.

B. The minimum wall thickness of steel casing should be 0.125 inches.

C. The ends of sections of casing should be threaded or bevelled for welding.

D. All casing is to be new black pipe free of interior coatings.

3.5–05 Grout Mix

A. Cement. Cement should be Portland Cement® Type I in acconformance with ASTM C 150. The cement should be delivered to the job site in 94 pound sacks. The use of Hi Early® Type III Cement and other quick setting cements is prohibited unless authorized by the Owner's Representative.

B. Water. Water should be obtained from the source designated by the Owner's Representative.

C. Hydrated Lime. Hydrated lime should be ASTM C 207, Type S, furnished in sacks. Hydrated lime should not contain air entrainment additives.

D. Bentonite. Bentonite should be powdered Sodium Bentonite furnished in sacks without additives.

E. Proportions. Cement should be mixed with water in the proportions of five to six gallons of water per sack of cement. Hydrated lime may be substituted for cement up to ten percent by volume. Between two and four pounds of bentonite powder should be added to the mix for each sack of cement used.

F. The grout should be thoroughly mixed with a paddle type mechanical mixer or by circulating the mix through a pump until all lumps are removed. Grout which is lumpy should be rejected.

G. Grouting Lines. All hoses, tubes, pipes, water swivels, drill rods or other passageways through which the grout will be pumped should have an inside diameter of at least 0.50 inches.

H. Grouting Procedure. Grout should be injected under pressure to displace water and cuttings from the level immediately above the seal placed above the screened zone up to the top of the well hole. Grout injection should be deflected to the sides and continued until clean grout flows out the top of the well hole.

I. Grouting of Multi–Cased Wells. For wells that penetrate multiple aquifers, WMI requires the installation of multiple or telescoping casing utilizing special grouting and construction techniques. WMI requires that a minimum 2 inch annular space be maintained between telescopic reductions (i.e., a 2 inch diameter screen will require first setting a 6.5 inch diameter casing in an 11 inch diameter boring). After the outer boring has penetrated not less than 2 feet of the first targeted aquitard, an outer casing is lowered to the

bottom of the boring. A tremie line is then installed through an inflatable packer and this entire assembly is lowered through the casing to within 3 feet of the bottom of the casing. After the packer is inflated, grout is injected through the tremie line until the entire annular space between the casing is filled and the grout returns to the surface. The casing string may have to be lifted 1–2 inches off the bottom of the boring to facilitate the even distribution of grout in the annular space. The grout should be allowed to cure for not less than 48 hours before drilling through the grout plug at the bottom of the casing and advancing the borehole through the next aquifer. This step is repeated for each separate aquifer unit. Upon reaching the final target depth, the inner casing and screen is set through the outer casing. Subsequent to the placement of the gravel, filter packs, and bentonite seal, the remaining annular space is grouted in the same manner as described in Section 3.5–05H.

J. Grouting Set Time. The well should not be disturbed for at least 48 hours after grouting to allow the grout to set up and gain sufficient strength.

K. Samples Required. Samples of grout should be taken inaccordance with Section 3.4–02H.

3.5–06 Gravel Pack

Gravel pack is the material placed in the annular space around the well screen.

A. Gradation. Gravel pack should be uniformly graded sand or gravel comprised of hard durable particles washed and screened with a particle size at least four times the d–15 size (15 percent of the soil is finer than the d–15) of the formation and no more than four times the d–85 size of the formation soil.

B. Purity and Decontamination. If necessary or directed by the Owner's Representative, the gravel pack should be decontaminated in accordance with Section 3.2–04.

C. Samples. Samples of gravel pack should be retained by the Contractor for 6 months in accordance with Section 3.4–02F.

3.5–07 Filter Pack

The filter is the layer of material placed in the annular space between the gravel pack and the bentonite seal.

A. Gradation. The filter should be uniformly graded fine sand with a 100 percent by weight passing the No. 30 sieve, and less than 2 percent by weight passing the 200 sieve.

B. Samples. Samples of filter should be obtained in accordance with Section 3.4–02G.

3.5–08 Bentonite Pellets or Chips for Seals

Bentonite pellets are a commercial product consisting of compressed bentonite balls and sand.

A. Composition. The Bentonite pellets should be from a commercial source free of contaminants.

B. Size. The diameter of the pellets should be less than one–half the width of the annular space into which they are to be placed.

Bentonite chips are a coarse grade Wyoming bentonite consisting of a natural sodium base bentonite.

A. Composition. The pebble–size chips of bentonite should be natural, unaltered mineral with no contaminants or added chemicals.

B. Size. The diameter of the chips should be less than one–half the width of the annular space into which they are to be used.

SECTION 3.6 – WELL SCREEN, RISER, AND SAMPLER INSTALLATION

3.6–01 General

This section covers the placement of the well screen, gravel pack, seals, and annular grout in a well hole. The specifications relative to drilling and temporary stabilization of the well hole are covered in other sections. This section includes removal of the temporary casing and placement of the permanent well protector and sampling system.

A. Stable Borehole. A stable borehole should be constructed prior to attempting to install the well screen. If the borehole tends to cave or "blow out," the Contractor should take steps to stabilize the well hole before attempting installation of the well screen. Boreholes which are not plumb or are partially obstructed should be corrected prior to attempting the installations described herein. Jetting or driving the well screen should not be permitted.

B. Sequence. The sequence of operations described herein should be adhered to unless a specific agreement is made with the Owner's Representative.

3.6–02 Assembly of Well Screen and Riser

A. Handling. The well screen including the bottom plug and/or wash out nozzle approved by the Owner's Representative should be decontaminated as described in Section 3.2–03 immediately prior to assembly. The workmen should take precautions to assure that grease, oil, or other contaminants do not contact the well screen. The workmen handling the well screen should wear a new pair of cotton or surgical gloves while handling the well screen. To prevent kinking of the threads, no more than 15 feet of screen or riser pipe should be assembled above ground.

B. Teflon Taped Joints. The male threaded part of each joint should be wrapped with Teflon® tape. Joints should be tightened by hand; however, if necessary, decontaminated pipe or chain wrenches may be utilized. The well screen and riser will be inserted into a well hole which is at least partially filled with water.

C. Ballasting the Riser. The well screen and riser should be ballasted to counteract the tendency to float in the borehole by continuously filling the string of riser pipe with water from the approved source. Preferably water should not be added, but the riser should be slowly pushed into the water in the borehole with the aid of the hydraulic ram and held in place with chains as additional sections of riser are added to the string.

3.6–03 Setting the Well Screen

The well screen should be lowered to the predetermined level and held in position by suspending the string of riser pipe or, if the string tends to float, by manipulating the hydraulic ram. On deep holes where the weight of the string of riser pipe is significantly more than the flotation force, care should be taken to keep the riser pipe plumb. The riser should extend above grade at least 3 feet. The riser should be trimmed to the proper length after the grout is in place. If the plumbness of the riser is especially critical or the well is extremely deep, a 10 foot pipe section at 0.90 times the inside diameter of the casing should be lowered down the inside of the riser to verify that the riser is not kinked.

3.6–04 Placement of the Gravel Pack

A. Volume of Gravel Pack. The volume of gravel pack required to fill the annular space between the well screen and the well hole should be computed and carefully measured out. The gravel pack should typically extend 5 feet above the uppermost row of slots in the well screen or to 5 feet above the top of the granular zone being monitored, except where limited separation between aquifers occurs.

B. Centering the Well Screen. The well screen should be centered in the well hole and temporary casing by pouring in approximately ten percent of the gravel pack then placing a centering disk over the riser and tamping the disk into place with the seal tamper. The remaining gravel pack should be placed in increments with centering disks as required to assure that the well screen is centered. The level of each layer of gravel pack filter and seal should be verified and recorded.

C. Withdrawal of the Temporary Casing/Augers. While holding the riser pipe with the drill rig, the temporary casing or hollow stem augers should be carefully withdrawn such that the lowermost point on the casing is exactly at the top of the gravel packed portion of the well hole. This may be accomplished in increments; however, after each increment, a centering disk and the seal tamper should be inserted and slid down to ascertain that the gravel pack has not bridged and raised during casing withdrawal operation. If necessary, the gravel pack should be tamped back into place with the centering disk. Check the level of the gravel pack relative to the well screen. Additional gravel may have to be added after auger withdrawal.

3.6–05 Placement of the Filter

A volume of filter sand which will extend a distance of 2 feet up the annular space from the top of the gravel pack should be carefully measured out. The filter should be poured into the annular space through a clean, flush threaded, 1 inch PVC pipe lowered to within 3 feet of the placement interval. If the level of water in the well hole extends above the gravel pack, the seal tamper or a jetting tube should be used to stir up the filter and prevent the segregation of the filter as it settles in the water in the well. The bottom of the temporary casing should be raised to a level at least five but no more than 10 feet above the gravel pack. Where conditions warrant, the filter may be eliminated. The Contractor should evaluate the need for the filter considering the gradation of the gravel pack, the hydraulic head, and the potential for grout intrusion into the gravel pack.

3.6–06 Placement of the Seal

A volume of bentonite pellets to create a seal three to 5 feet long should be measured out and carefully poured into the annular space. If the bentonite seal is being constructed above the water level in the well hole, exactly five gallons of water should be poured into the annular space. The seal tamper should be lowered down and utilized to tamp the pellets into a cohesive mass of clay. Alternatively, a heavy bentonite slurry may be carefully tremied into the annular space to form the required seal.

3.6–07 Grouting the Annular Space – Single Cased Wells

A. Volume of Grout. The volume of grout required to completely fill the annular space between the seal and the ground surface should be prepared in the proportions specified in Section 3.5–05. The volume should include a quantity to compensate for losses. The end of the tremie pipe should be equipped with a deflection plate or side discharge to prevent displacement of the filter and gravel pack materials.

B. Injection Procedures. The grout should be injected via a tremie pipe (side discharges), the opening for which is temporarily set immediately above the seal. The grout should be pumped into the tremie pipe continuously until it flows out at the surface.

C. Casing Removal. The temporary casing/auger should be removed immediately and in advance of the time when the grout begins to set. Casing removal and injection may proceed concurrently provided the top of the column of grout is maintained at least 20 feet above the bottom of the casing and provided injection is not interrupted. If casing removal does not commence until grout injection is completed, then additional grout should be periodically poured into the annular space so as to maintain a continuous column of grout up to the ground surface.

D. Grout Setting and Curing. The riser pipe should not be disturbed until 48 hours after grouting is completed except for water level measurements made using an electronic water level indicator. Trimming of the riser pipe may be completed while the grout is plastic or at least 48 hours after the hole is grouted. Trimming should not be attempted during the interim period. Precautions should be taken to prevent pipe cuttings from entering the riser.

3.6–08 Well Protector

Anodized aluminum well protector, as shown on the drawing, should be set in the neat cement. The well protector should be positioned and maintained in a plumb position. A 6 inch clearance between the top of the riser and the well protector should be maintained for the sampler. This can best be accomplished by placing a 6.0 inch piece of trimmed or notched 6 inch wood stock between the well riser and the cap. Grout which has overflowed the well hole should be carefully removed so as to prevent the formation of horizontal projections (mushrooming) which may be subject to frost heave. A 1/4 inch diameter hole should be drilled in the well protector 6 inches above the ground surface to permit water to drain out of the annular space. Dry bentonite pellets should be placed in the annular space below ground level. Coarse sand and pea gravel should be placed in the annular space above the dry bentonite pellets and hole to prevent insects from entering through the drill hole.

3.6–09 Installation of the Sampler

The sampler is to be installed in accordance with the manufacturer's instructions after completion of well development.

SECTION 3.7 – WELL DEVELOPMENT AND ACCEPTANCE

3.7–01 General

This section covers the purging and development of a newly constructed well, the measurement of the well characteristics, and the initial sampling and on-site water quality testing. Also described is the acceptance criteria for a completed well.

3.7–02 Pumps for Well Development

A. General. All wells should be pumped or evacuated using filtered compressed air or nitrogen to produce representative formation water. This section describes the approved pumps and appurtenant works to be utilized in development of monitoring wells. All pumps and other devices used in well development should be decontaminated as specified in Section 3.2–05.

B. Submersible Pumps. Submersible pumps should include electric motor powered centrifugal or positive displacement type pumps which are operated under submergence. If a submersible pump is utilized for well development, it should be of a type and capacity such that it can pump water from the well continuously for a period of at least fifteen minutes without shutting off. Backpressure or other methods may be utilized to accomplish the desired rate of pumping. The pump should be capable of being turned on and off instantaneously to create surges in the well. The pump should be fitted with a check valve.

C. Bladder Pumps. A bladder or diaphragm pump is a type of pump which operates under the cycling of compressed air. The compressed air cycling inflates and deflates a diaphragm which creates a pumping action. Bladder pumps approved for well development should be capable of pumping at least 1 gpm continuously when installed in the well.

D. Jet Pumps. A jet pump utilizes the Venturi principle to create subatmospheric pressure which allows a suction pump to be utilized below a depth at which suction alone would not normally lift the water. Jet pumps approved for well development should be capable of pumping at least 3 gpm continuously when installed in the well.

E. Suction Pumps. Suction pumps should not be utilized in wells the depth of which exceeds 20 feet. Suction pumps used to develop wells less than 25 feet deep should be capable of pumping at least 5 gpm continuously without pumping the well dry in less than 5 minutes.

F. Bailers. Bailers should not be utilized for well development except after an approved submersible, bladder, jet, or suction pump has been installed in the well or compressed air or bottled nitrogen has been used, and the rate of well recovery is so slow that these methods are ineffective.

G. Compressed Air. Compressed air supplied by an engine–driven compressor equipped with an approved oil trap and filter may be utilized provided the source of compressed air is capable of evacuating 50 percent of the column of water from the well once every minute.

H. Bottled Nitrogen. Bottled nitrogen may be utilized provided a regulator is employed and the system is capable of evacuating 50 percent of the column water from the well once every minute.

3.7–03 Periods of Well Development

A. General. Well development should be continued until representative formation water free of the effects of well construction is obtained. Representative formation water should be assumed to have been obtained when pH, temperature, and conductivity readings are stable and the water is clean, and the minimum periods of development specified herein have been

completed. Testing of pH, temperature, and conductivity should be performed by the Contractor; however, the Owner may perform the testing or direct others to perform the testing which should not relieve the Contractor of his responsibility to develop the well until acceptance.

B. Period of Development. The minimum period of well development should be in accordance with the following guidelines depending on the well development procedure selected.

1. Pumping with a Submersible Pump. Four hours.

2. Pumping with a Bladder Pump. Eight hours.

3. Pumping with a Jet Pump. Four hours.

4. Pumping with a Suction Pump. Four hours.

5. Compressed Air. Four hours cycling at two minute intervals.

6. Bottled Nitrogen. Four hours cycling at two minute intervals.

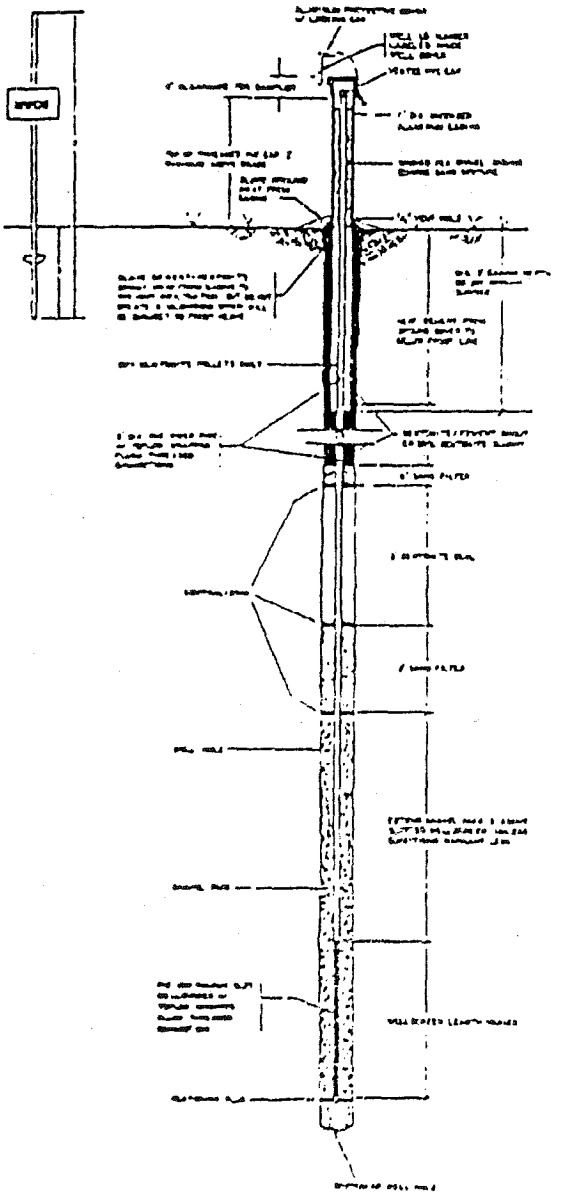
7. Bailers. Eight hours continuously alternating two men. This method to be used only if all other methods prove infeasible.

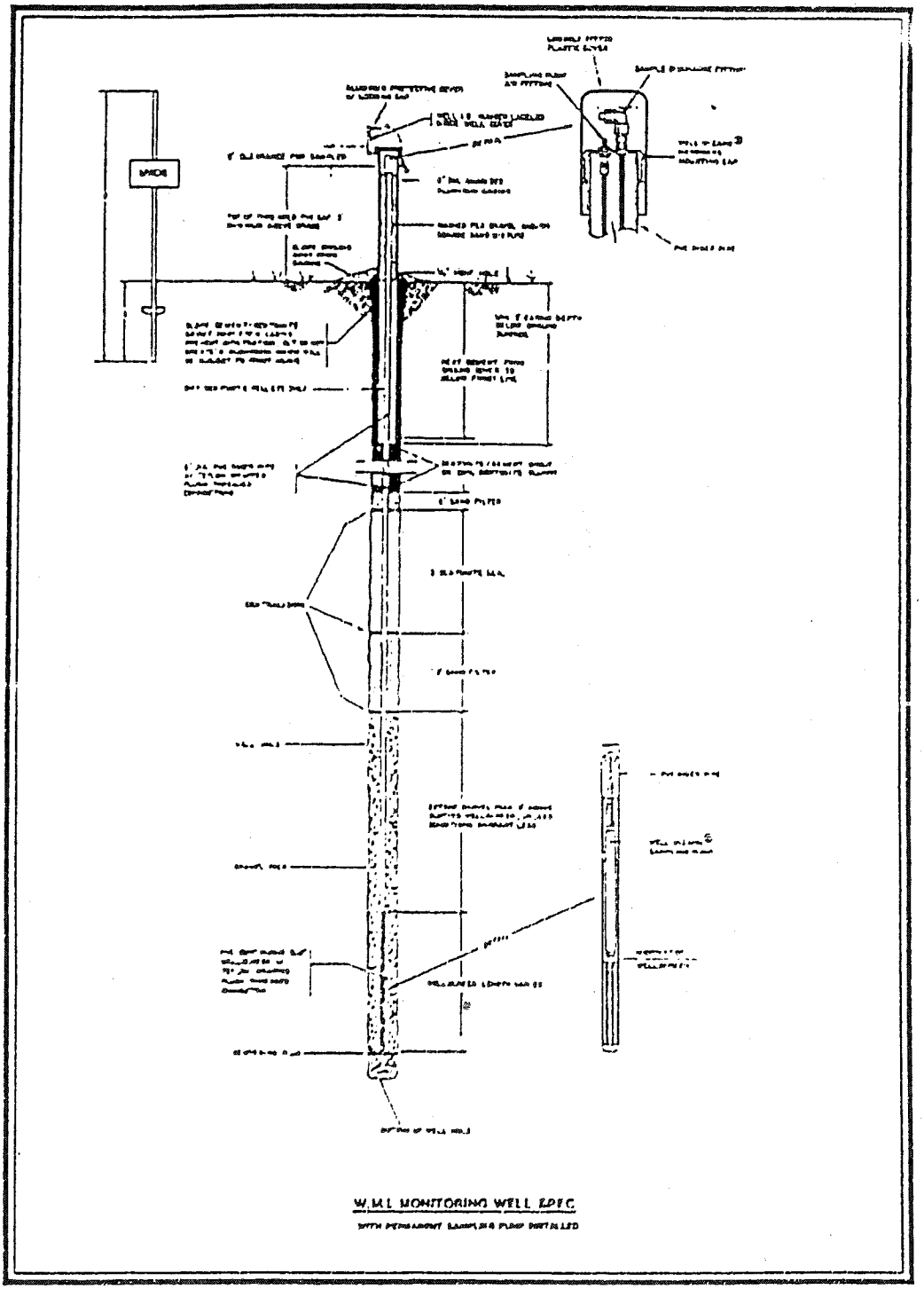
3.7–04 Well Recovery Test

A well recovery test should be performed immediately after development by the Contractor. Readings should be taken at one minute intervals until the well has recovered to its static water level.

3.7–05 Well Acceptance

A well will be accepted by the Owner's Representative when development has been completed in accordance with these specifications, and the documentation required under Section 3.1–03 is furnished to the Owner's Representative. Once a well has been approved, the Contractor should be relieved of any further responsibility for the performance, maintenance, or testing of that well.





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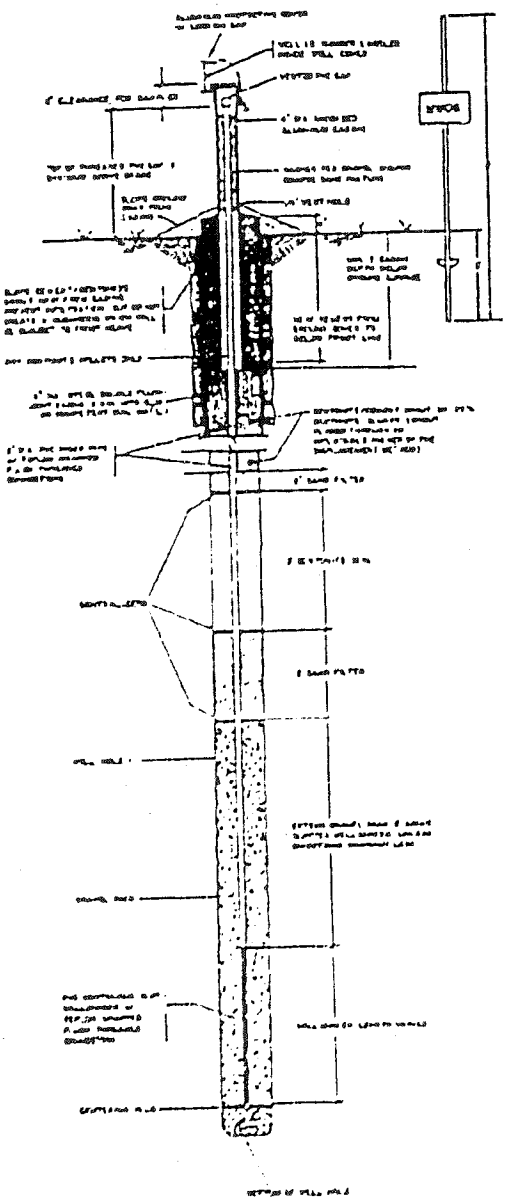

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